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View of the Chalk Escarpment of the North Downs, looking westward from near Folkestone.

Beachborough Summer-house. Castle Hill. Sugar-loaf Hill.

MEMOIRS OF THE GEOLOGICAL SURVEY, ENGLAND AND WALES.

THE GEOLOGY OF THE WEALD,

(PARTS OF THE COUNTIES OF KENT, SURREY, SUSSEX, AND HANTS.)

BY

WILLIAM TOPLEY, F.G.S., Assoc. Inst. C.E.

(In part from the Notes and MSS. of H. W. Bristow, F.R.S., W. T. Aveline, F.G.S., F. Drew, F.G.S., C. Gould, B.A., F.G.S., and Dr. C. Le Neve Foster, B.A., F.G.S.)

Lists of Fossils revised by R. Etheridge, F.R.S., L. & E., Palæontologist to the Survey.

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THE preparation of this Memoir has been accompanied by considerable difficulty, from the circumstance that, of nine gentlemen engaged in the Survey of the Wealden Area, six left the Survey, and one died, before the completion of the work. I nevertheless believe that the Memoir will be found eminently satisfactory, in consequence of the ability shown by MR. TOPLEY in correlating the notes and other descriptive writings left by most of the Surveyors; while the Palæontological lists have been revised by MR. ETHERIDGE with his usual ability.

A. C. RAMSAY,

5th December 1874. Director General.

THE Geological Survey of the extensive tract of country treated of in this Memoir, and familiarly known as the Weald, was commenced in 1855.

The larger part of the district was surveyed by Mr. Drew, who first worked out and described the subdivisions of the Hastings Beds. Mr. Drew left the Survey in 1862; but before doing so he wrote a description of such parts as he had surveyed, much of which is incorporated in this Memoir. Considerable areas were worked out by Mr. Gould and Dr. C. Le Neve Foster, who have also left MS. notes of much value. Other and smaller areas were surveyed by Messrs. Aveline, Hay, Polwhele and Dawkins.

Some parts, more especially in the neighbourhoods of Cuckfield, Uckfield, and Lewes, were mapped by myself. The details of the geology of the country around Cuckfield were worked out while instructing in field-surveying the late Mr. F. C. Bishopp, a young man who in his short period of service gave great promise as a practical geologist.

The preparation of the Memoir on the whole area was entrusted to Mr. Topley, who, with the assistance of the notes and previously-published Memoirs of his colleagues, has described its geological structure and physical geography more completely than has ever been done before; and in a way which, it is believed, will prove equally creditable to himself and the Survey.

The lists of Fossils in the text, and the copious Tables contained in Appendices I. and II., have received the careful and critical revision of Mr. Etheridge, Palæontologist to the Survey.

The Bibliography, which Mr. Topley has appended to the Memoir, greatly adds to its value and usefulness, by furnishing a complete and exhaustive list of the

works of previous authors on that part of England of which his own Memoir more especially treats.

A Geological Model of the south-east of England has been published by Mr. Topley and Mr. J. B. Jordan, of the Mining Record Office. This model shows the relation of the geological structure of the district to its physical features, and well illustrates many points which are discussed in this Memoir.

H. W. Bristow,
Director.

Geological Survey Office,
28, *Jermyn Street, London, S.W.,*
1*st December* 1874.

PREFACE.

The Geological Survey of the Weald was commenced in 1855 by MR. H. W. BRISTOW, who, in the autumn of that year, drew the line between the Chalk and the Upper Greensand in the neighbourhood of Lewes. Here he was joined by MR. F. DREW, who, up to the time of his leaving the Survey in 1862 was continuously engaged in the Weald.

The Upper Cretaceous and Lower Greensand boundaries were first drawn, and it was not until these were completed that the Survey of the Weald proper, or the central country, was commenced.

The Upper Greensand, Gault, and Lower Greensand areas of Kent and Surrey were wholly surveyed by MR. DREW. Those of Hampshire by MR. BRISTOW and MR. DREW. The line between the Chalk and Upper Greensand in Sussex was mainly drawn by MR. BRISTOW; the Gault and the Lower Greensand areas west of Lewes were surveyed by MR. C. GOULD, those on the east of that town by MR. C. GOULD and MR. T. R. POLWHELE.

The Survey of the Hastings Beds was commenced at Hastings, in 1858, by MR. DREW and MR. GOULD. The latter remained at Hastings, surveying much of the country around that place and Battle; a work which was afterwards continued and completed by MR. W. T. AVELINE. MR. DREW commenced the Survey of the northern part of the Hastings Beds at Tunbridge Wells; working first to the west to join the lines which MR. J. HAY had drawn near Horsham; afterwards continuing the work to the east and south-east.

DR. C. LE NEVE FOSTER surveyed some of the country near Hawkhurst, and much of that near Mayfield, Wadhurst and Burwash; afterwards completing a smaller area near East Hoathly. The country around Warbleton, and some of that near Brede, was surveyed by MR. W. BOYD DAWKINS. MR. BRISTOW worked out the country around Cuckfield, and that on the west and south-west of Uckfield; aided, in the last-named district, by MR. F. C. BISHOPP. My own work, in detailed surveying, was chiefly along a line of country lying between Burwash and Lindfield; but I have had numerous opportunities of becoming acquainted with the entire district.

The Gravels were separately mapped at a later date. Those of the Stour and the greater part of those of the Medway were surveyed by DR. FOSTER and myself. I am responsible for those of the Darent. The gravels of the other rivers were surveyed by MR. DAWKINS, who also mapped some at the extreme east and west ends of the Medway basin. MR. C. E. HAWKINS is now engaged in re-surveying parts of these areas and in dividing the gravel from the brickearth.

The Horizontal Sections were constructed by MR. BRISTOW, DR. FOSTER, and myself; MR. DAWKINS aiding in a small part of Sheet 78.

It will thus be seen that the larger part of the area has been surveyed by MR. DREW, who, on resigning his appointment, left many valuable notes and MSS., which have been used in this Memoir. MR. GOULD also left descriptions of the areas surveyed by him.

I trust that the Bibliographical list (which owes its completeness very largely to MR. WHITAKER'S assistance) will prove of value to those who may hereafter work at the Geology of the Weald; where, notwithstanding the long array of authors who have written upon it, very much yet remains to be done. I could have wished that the references in the text had been more numerous and complete; but the greater part of the Memoir has been written during intervals taken from field-work in other districts, often amongst Northumbrian moors, and generally at a distance from libraries. Under such circumstances literary work, involving bibliographical research, is carried on at considerable disadvantage. My best thanks are due to MR. W. LYALL, the librarian of the Literary and Philosophical Society of Newcastle, for the facilities he has granted me in consulting the valuable library under his charge.

It is a pleasing duty to record here the numerous acts of kindness, and the great assistance derived by the Geological Survey, from many residents in the district. I may especially mention:—the late MR. W. H. BENSTED, of Maidstone; MR. CLARKE, of Sandgate; MR. R. GODWIN-AUSTEN, then of Chilworth, now of Shalford; the late MR. W. HARRIS, of Charing; MR. H. B. MACKESON, of Hythe; the late MR. P. J. MARTIN, of Pulborough; DR. H. ROGERS, of East Grinstead; and MR. H. WILLETT, of Brighton.

W. TOPLEY.

Geological Survey Office,
28, *Jermyn Street, London, S.W.*
November 2, 1874.

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GEOWALES

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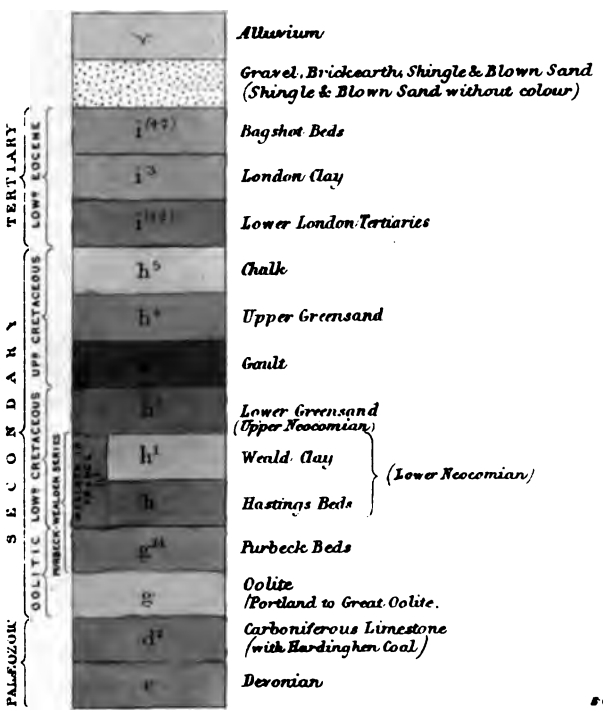

The General Dip of Beds is indicated by an arrow

SCALE

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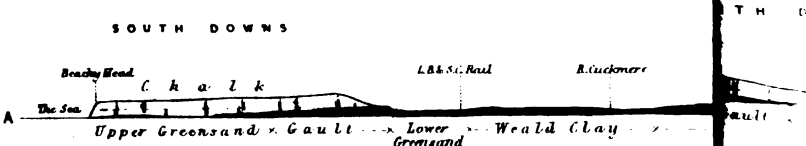

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The Topography electrotyped by the Ordnance Survey, from the Index Map.

GEOLOGY OF THE WEALD.

PART I.

INTRODUCTORY.

CHAPTER I.—GENERAL SKETCH OF THE DISTRICT AND TABLE OF STRATA.

The Wealden Area, of which this Memoir treats, is one of the best defined geological tracts in England. Its boundary is the Chalk escarpment, which, commencing at Folkestone Hill near the Straits of Dover, passes through the counties of Kent, Surrey, Hants, and Sussex, to the sea at Beachy Head. The oval-shaped area thus enclosed is what geologists have termed the Weald; but the district anciently included under that term was probably generally bounded by the Lower Greensand escarpment. Where, however, the latter escarpment is low and ill defined, there the boundary of the Weald was doubtful; but as regards the boundary of the geological area known as "The Weald," there can be no mistake.

Whilst, however, the district of which we have now to treat is thus well defined by a striking physical feature, this feature is not (or only very rarely) a boundary for any of the political divisions of the counties. Manors, parishes, registration districts, and parliamentary divisions alike ignore it.

The Wealden Area embraces the south-western part of KENT (nearly one half of its total area), and includes the following towns:—Ashford, Cranbrook, Edenbridge, Folkestone, Goudhurst, Hythe, Lydd, Maidstone, New Romney, Sevenoaks, Tenterden, Tunbridge, Tunbridge Wells, and Westerham. The southern part of Surrey (about two-fifths of the county), including:—Cranley, Dorking, Farnham, Godalming, Godstone, Haslemere, and Reigate. The north and north-eastern parts of SUSSEX (about three-fifths of the county), including:—Battle, Cuckfield, Eastbourne, East Grinstead, Hailsham, Hastings and St. Leonard's, Horsham, Mayfield, Midhurst, Petworth, Pulborough, Rye, Steyning, Uckfield, and Winchelsea. A small part of HAMPSHIRE, on its eastern side, including:—Petersfield and Selbourne.*

* Guildford (in Surrey) and Lewes (in Sussex) are on Chalk; both are built close to the Wealden border, on the banks of rivers which drain the Weald.

TABLE OF STRATA EXPOSED WITHIN THE WEALD.

									Feet.
	SUPERFICIAL DEPOSITS.	Recent					Alluvium and Submarine Forests.		
							Blown Sand.		
							Shingle.		
		Post Pliocene					Gravel and Brickearth (Old River Deposits).		
Marine	UPPER CRETACEOUS.				Upper Greensand				0 to 80
					Gault				? 60 to ? 150
		Upper Neocomian.			Lower Greensand, 70 to 500 ft.	Folkestone Beds			? 70 to ? 180
						Sandgate Beds			0 to 100
						Hythe Beds			? 25 to 300
						Atherfield Clay			0 to 60
Fluvio-Marine (Punfield Formation).	LOWER CRETACEOUS.	Lower Neocomian.	Wealden Beds		Weald Clay				? 400 to ? 1,000
Fresh-Water					Hastings Beds.	Tunbridge Wells Sand 160 to ? 380 ft.	Upper Tunb. W. Sand (with Cuckfield Clay).		100 to 200
							Grinstead Clay		0 to 80
							Lower Tunb. W. Sand		30 to 130
						Wadhurst Clay			100 to 180
						Ashdown Sand	Ashdown Sand		150
							Fairlight Clays		360
Fluvio-Marine	OOLITE				Purbeck Beds	(*Ashburnham Beds*)			? 400

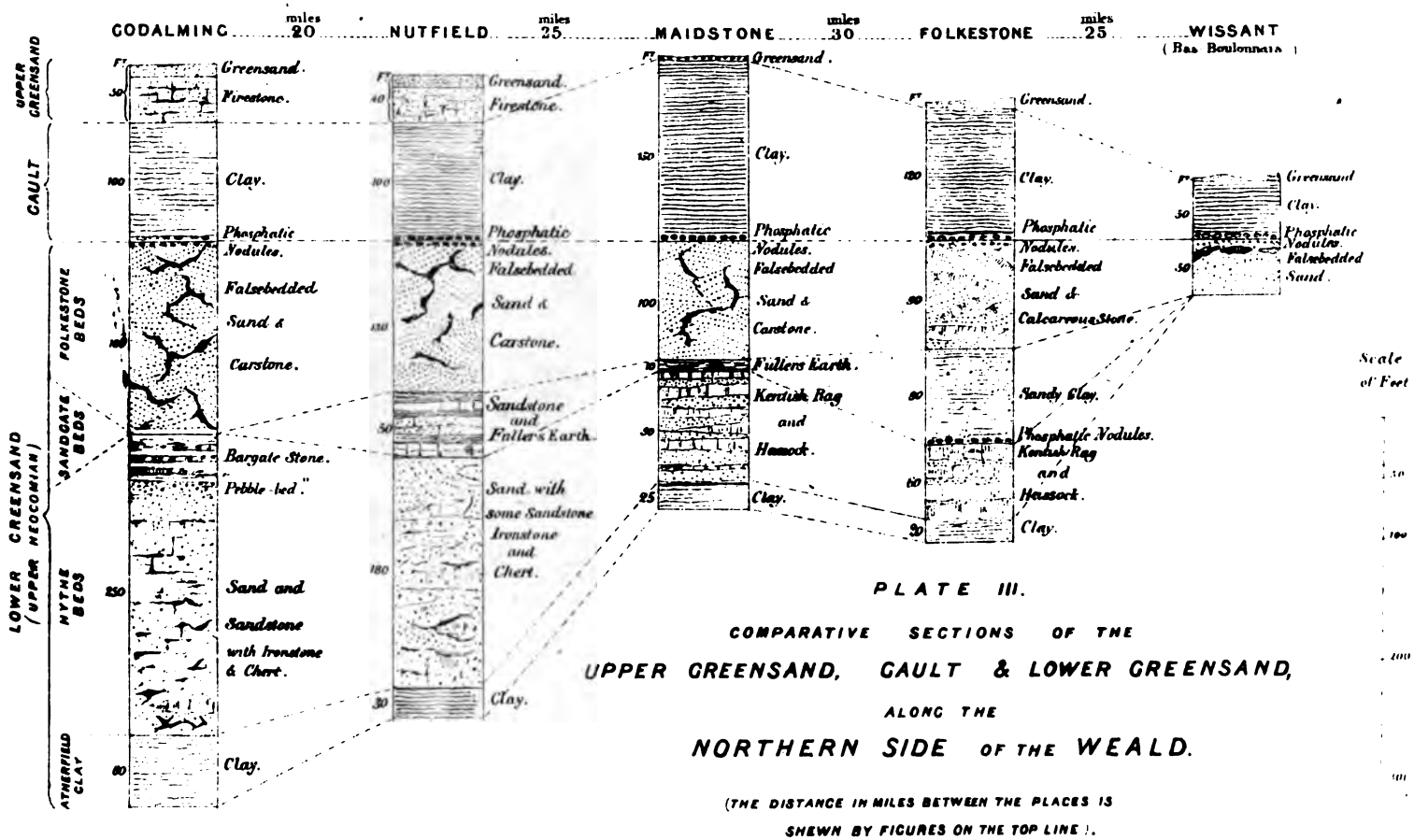

PLATE III.

COMPARATIVE SECTIONS OF THE

UPPER GREENSAND, CAULT & LOWER GREENSAND,

ALONG THE

NORTHERN SIDE OF THE WEALD.

(THE DISTANCE IN MILES BETWEEN THE PLACES IS SHEWN BY FIGURES ON THE TOP LINE).

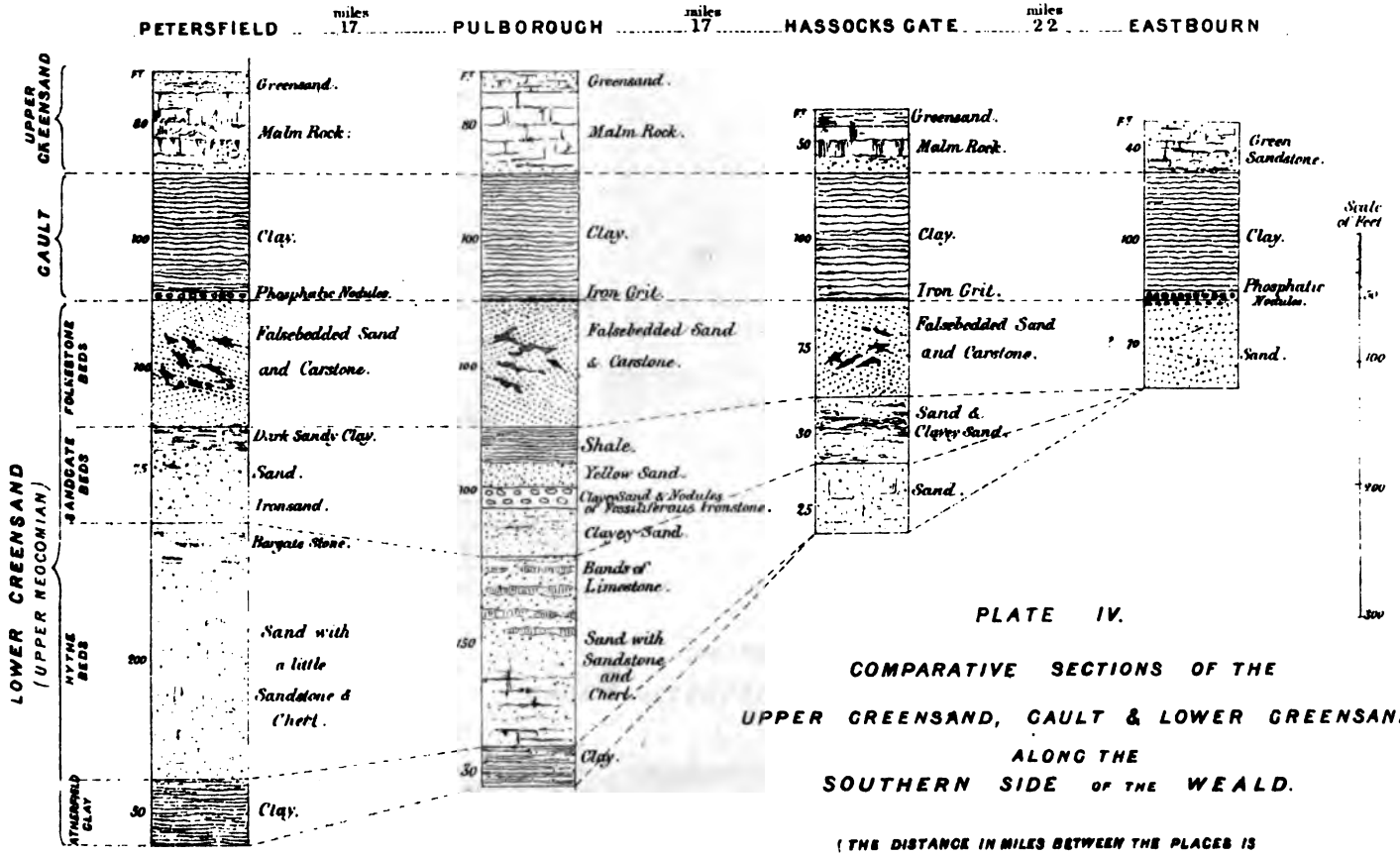

PLATE IV.

COMPARATIVE SECTIONS OF THE UPPER GREENSAND, CAULT & LOWER GREENSAND, ALONG THE SOUTHERN SIDE OF THE WEALD.

(THE DISTANCE IN MILES BETWEEN THE PLACES IS SHEWN BY FIGURES ON THE TOP LINE).

Geological Formations of the District.

These are shown in a tabular form on the adjoining page, and comparative sections of the strata are given in Plates III., IV., and V.

In the subsequent detailed description, the beds will be noticed in ascending order, as we can by this method best understand the structure of the country. In the following brief and general remarks they will be noticed in descending order, as they appear in the tables and sections.

Superficial Deposits.—These lie indiscriminately on all the older strata, and no formal description of them can well be given here. It may suffice to say that the formation most covered by river deposits, whether modern alluvium or old river terraces, is the Weald Clay; next to this, in the extent of its superficial covering, comes the Lower Greensand. The Hastings Beds are only very slightly obscured by gravels, but there are wide spreads of alluvium in the valleys which lead into the broad alluvial tracts of Romney Marsh and Pevensey Level.

Chalk.—Although often mentioned in the following pages, this formation is not described in this Memoir. The Chalk north and north-west of the Weald has been described by Mr. Whitaker in the Memoir on the London Basin, Part. I.*

Upper Greensand.—This division is well developed through Sussex, Hants, and the greater part of Surrey. In Kent it is thin and sometimes apparently absent. There is no strongly marked line dividing the Upper Greensand from the overlying Chalk nor from the underlying Gault.

Gault.—This division has less variations in character than any other bed with which we are concerned. It is remarkable too that the Folkestone Beds, which underlie it, are the most constant of the Lower Greensand divisions. Between these two formations there is a great palæontological break. In other parts of England there is a partial break in succession, the Gault overlapping the Lower Greensand and resting on lower beds; nothing of this kind occurs in the Weald, so far as we can judge. If it were so one would expect to find the Folkestone Beds exceedingly variable in thickness, and sometimes absent.

The average and usual thickness of the Gault is about 100 feet; but it seems to be much thinner than this between Dorking and Guildford, whilst near Aylesford it appears to be unusually thick.

Lower Greensand.—(*Upper Neocomian.*)—This formation has been mapped as one bed in the eastern part of Sussex, but through-

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* *Mem. Geol. Survey*, vol. iv., 1872. The Chalk on the South of the Weald has been described by Dr. Mantell, in his various works; by Mr. F. Dixon, in his Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, 4to, 1850; and by Mr. Whitaker, *Geol. Mag.*, vol. viii. p. 198.

In the Museum at Brighton there is an excellent collection of Chalk fossils, chiefly from Sussex, collected and presented by Mr. Henry Willett. A Catalogue of this collection has been published. 8vo. Brighton, 1871.

out the rest of the district some subdivisions, generally well marked, have been established. Of these there are four in all, but only two can be constantly recognised. As a whole, the Lower Greensand, like the Upper Greensand, thickens in a westerly direction, as is shown in the sections (Plates III. and IV.); where best developed it spreads over a considerable tract of country, and ends in a bold escarpment overlooking the Weald Clay.

The divisions of the Lower Greensand are :—

1. The *Folkestone Beds.*—These are thickest at the north-western part of the Weald, and are of a sandy character.
2. The *Sandgate Beds.*—This division contains a good deal of clay, and (in Kent and Surrey) Fuller's earth. It is well developed in the western part of Sussex, in East Kent, and on the borders of Kent and Surrey.
3. The *Hythe Beds.*—These are most strongly marked off from the other divisions in Kent, but they attain their greatest thickness at the north-western part of the district.
4. The *Atherfield Clay.*—This division consists of clay with, in places, some bands of calcareous rock. It is thickest in the western part of the district, and thins gradually going east along the southern side of the Weald; in the eastern part of Sussex it has not been recognised. It can be traced all through Surrey and Kent, thinning slightly in an easterly direction.

Wealden Beds.—This fresh-water formation is divided into two great groups, an upper one, the Weald Clay, and a lower one, the Hastings Beds; in the latter several subdivisions have been established.

Weald Clay.—This, the highest division of the Wealden Beds, attains a thickness of nearly 1,000 feet on the west of Horsham, but it thins gradually in an easterly direction. This is known to be the case on the north side of the Weald, and the same thing is believed to occur even more rapidly on the south side of the Weald. The greater part of this division consists of clay and shale, but it contains some beds of sand, calcareous sand, and shelly limestone.

Tunbridge Wells Sand.—This division, like the foregoing Lower Cretaceous groups, thickens considerably in a westerly direction. In the eastern part of the Hastings Beds area it has been mapped entire; but there is generally a clayey bed near the bottom which to the west becomes of some importance, and is then separately mapped under the name of the Grinstead Clay. The sands above and below this clay are then known as the Upper and Lower Tunbridge Wells Sand. In the neighbourhood of Cuckfield the Upper Tunbridge Wells Sand is itself divided by a bed of clay —the Cuckfield Clay.

Wadhurst Clay.—This bed is very constant in its character, consisting almost entirely of clay and shale. Sometimes in its lower part there is a bed of sand; and close to the bottom there are nodules and occasional bands of clay-ironstone, the chief source

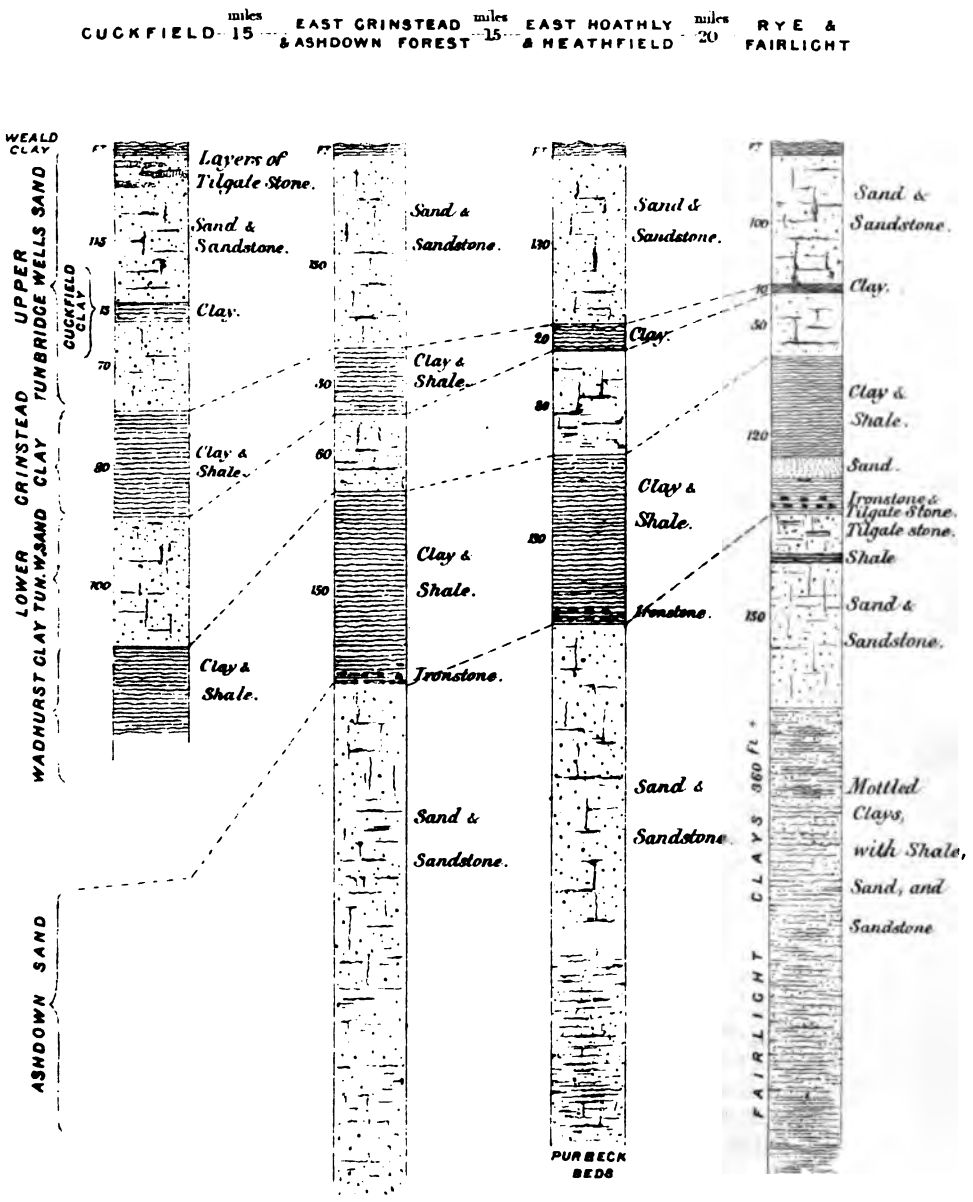

PLATE V.

COMPARATIVE SECTIONS OF THE

HASTINGS BEDS

(THE DISTANCE IN MILES BETWEEN THE PLACES IS SHEWN BY FIGURES ON THE TOP LINE)

Scale 0 50 100 200 300 Feet

Drawn by W. Topley

to face page 4.

of the iron ore of the old wealden furnaces. Calcareous sandstone also occurs in places. The Wadhurst Clay appears to attain its greatest thickness a little to the east of Tunbridge Wells.

Ashdown Sand.—This division occupies a large area of the higher part of the Hastings Beds country. It consists of sand and soft sandstone with some subordinate bands of clay. It is difficult to estimate the thickness of this division. In Ashdown Forest, where the base is nowhere reached, there cannot be less than 400 feet of strata exposed, and there may be nearly 500 feet; near Heathfield and Brightling there may be nearly as much. Here the lower part is generally more clayey than the upper part; whilst in the neighbourhood of Hastings and Fairlight, clays, frequently mottled, predominate in the lower part. These clays have been separately mapped in the Hastings district, and were termed "Ashburnham Beds," being coloured the same as the lowest known strata of the interior. They are now called *Fairlight Clays*, and it must be remembered that they represent the lower part of the Ashdown Sand further west.

Purbeck Beds.—These are only exposed over a small area on the north and north-west of Battle. They have hitherto been termed "Ashburnham Beds" by the Geological Survey, this being the name under which DR. MANTELL originally described them. As they contain estuarian shells, and differ in many ways from the overlying strata, it has been considered advisable to separate them from the Hastings Beds, and to colour them as Purbecks. They are of great economic importance from the quantity of limestone and gypsum they contain. The limestones occur chiefly on two horizons, separated by 100 or 140 feet of shale. The higher series is termed "the Greys," the lower "the Blues." The gypsum does not crop out to the surface, but has been found in the Sub-Wealden Boring.

In describing the area occupied by the Hastings Beds it will be impossible to trace each subdivision separately through the whole district; the country is so much disturbed by faults and folds that the various beds, for the most part, come with apparent irregularity to the surface, without occupying any great extent of country.

It will, perhaps, be most convenient to divide the central district into five divisions. The first will include only the Purbeck Beds; the last will include only the small area around Cuckfield; the others will have for their boundaries the River Rother and the streams flowing into the Medway and Ouse, taking Rotherfield as a central point where tributaries of these rivers rise. The five districts thus formed may be named as follows:—

a. The Purbeck Beds, on the north and west of Battle.
b. Hastings and Battle.
c. Tunbridge Wells and Cranbrook.
d. East Grinstead, including the whole of Ashdown Forest.
e. Cuckfield.

The various divisions, as in succeeding formations, will be described in *ascending* order, an arrangement which will have a special

advantage for the Hastings Beds area, for the lower beds are brought up mainly along the chief lines of elevation, and in first considering these we best get an idea of the structure of the country.

In describing the formations above the Hastings Beds we will take up each subdivision separately at its north-eastern limit and trace it from thence round the Weald.

The superficial deposits cannot well be treated in this way; they can best be divided according to the river-basins within which they occur.

Nomenclature employed by the Geological Survey.

Perhaps this subject could best be treated in the following Chapter, in which a short history of Wealden Geology is given; but it may be as well here to state the reasons why the terms now used have been adopted by the Survey.

The names of the great divisions were in common use long before the district was mapped, or indeed before the Geological Survey existed. DR. MANTELL had given names to some divisions of the Hastings Beds which were at first adopted (though not published) by the Survey; but it was soon found that DR. MANTELL had been misled by apparent similarity of succession in different parts of the Weald, and especially by the occurrence of beds of Tilgate stone and shelly limestone; it was therefore necessary to disuse his terms.

DR. MANTELL'S classification is as follows:—*

1. Weald Clay.
2. Hastings Beds.
   a. Horsted Sand.
   b. Tilgate Beds.
   c. Worth Sandstone.
3. Ashburnham Beds.

The *Horsted Sand* corresponds generally with the Tunbridge Wells Sand. The *Tilgate Beds* also belong generally to the upper part of the Tunbridge Wells Sand, but DR. MANTELL has also included in this division beds that are both lower and higher in the series (as the Wadhurst Clay of Hastings and the beds at Loxwood in the Weald Clay).

The *Worth Sandstone* around the place from whence it takes its name is the Lower Tunbridge Wells Sand of the Geological Survey; but at Hastings it is the Ashdown Sand.

The *Ashburnham Beds* [of MANTELL] include the lower part of the Ashdown Sand, or the beds now known as the Fairlight Clays, the limestone beds near Battle (Purbecks), and also the shelly bed at the bottom of the Wadhurst Clay, wherever DR. MANTELL had observed it.†

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* *Geology of the South East of England*, p. 182, 1833.

† The beds at Ashburnham, from whence the name is taken, are *Wadhurst Clay.*

MR. F. DREW, who mapped a large part of the Hastings Beds, gave to the various subdivisions the names which they now have. His reasons for doing so he states as follows:—* "Taking the "eastern part first: about Tunbridge Wells the upper sands "occupy a great space; they form nearly all the hills near; "and their top bed makes those conspicuous rocks that I have "spoken of. I think, therefore, their name is well taken from "that place. The clay beneath them is chiefly found in the "valleys about there; but near the large village of Wadhurst, "about seven miles to the south-south-east, it spreads over "some tolerably high ground, which is indented by a series of "valleys that expose a great thickness of it, and at last reach "down to the sands below; and its position with regard to these "can also be well seen in the cuttings at the ends of the Wadhurst "Tunnel. I have on these accounts thought it well to take the "name of *Wadhurst Clay* for the second stratum. The lower "sands make very high ground, are spread over a large area, and "show a very great thickness in Ashdown Forest, which is the "central part of all the Hastings Sand country; no name, I think, "can be better for these than *Ashdown Sands.* The bed of clay "that appears in the Tunbridge Wells Sand, and thickens to "[more than] 50 ft. to the westward, may well be called *Grin-"stead Clay*, from its occurring on the north side of the town of "East Grinstead, and making as large a spread near there as "anywhere else, and from its relation to the lower beds being "well seen in that neighbourhood. This clay of course divides "the sand into *Upper* and *Lower Tunbridge Wells Sand.*"

The only point in which the Survey followed DR. MANTELL was in retaining the term *Ashburnham Beds*, including under that term both the lowest strata of Sussex (exposed near Battle) and the clays at the base of the Hastings Cliffs. In this too it is now certain that DR. MANTELL was wrong, and therefore in this Memoir and in future editions of the Maps and Sections the term will be discarded. The limestones, &c. near Battle will be described as *Purbeck Beds;* and the clays of the Hastings Cliffs will be described as *Fairlight Clays*, a term employed by MR. C. GOULD when mapping the beds.

The divisions of the Lower Greensand in the Weald, excepting the Atherfield Clay, were established by DR. FITTON, but were not named by him. MR. DREW adopted for these divisions the names of places on the Kentish Coast at which the beds are respectively well exposed. The name of the lowest division, *Atherfield Clay*, is taken from Atherfield, in the Isle of Wight; this was used by DR. FITTON.

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* "On the succession of Beds in the 'Hastings Sand' in the Northern Portion of "the Wealden Area."—*Quart. Journ. Geol. Soc.*, vol. xvii. p. 283, 1861.

CHAPTER II.—SKETCH OF GEOLOGICAL LITERATURE RELATING TO THE DISTRICT.

The Wealden district, being a remarkably distinct and well-defined area, has received a large amount of attention from English Geologists. In Appendix I. will be found a detailed list of the papers and books which have appeared on this district. A very large proportion of them refer to the Weald only, or to some portion of it; the remainder are those treating of larger areas, or more general questions, but in which the Weald is described or discussed.

I here propose to draw attention to a few of these publications which seem to me to be noteworthy in the literature of the Weald itself, or in the influence which they have had upon the progress of geological inquiry in England.

Amongst the numerous authors who have written upon the Weald,* there are four whose works are especially worthy of note; they are DR. MANTELL, MR. MARTIN, DR. FITTON, and MR. GODWIN-AUSTEN.

DR. MANTELL first discovered and described the huge saurians, whose remains are the most remarkable fossils which the Weald has produced; he also did much to make known the stratigraphical relations of the central country. MR. MARTIN and DR. FITTON worked hard and long at the higher Cretaceous beds around the Weald; so well was their work done, that in many places they have left later writers but little to add, and still less to alter. MR. GODWIN-AUSTEN'S part in working out the geology of the Weald has been less extensive than that of the others, but he has done more than any (not excepting DR. FITTON) towards solving the problems which face us when we once pass beyond the mere details of stratigraphical geology; and no one can hope to understand the history of the Cretaceous rocks without repeatedly studying his papers.

The earliest work having any claim to notice is that of VERSTEGAN, published in 1605,† in which he showed by good geological reasoning that the Chalk of England was once continuous with that of France. The collateral arguments, considering the date at which they were advanced, are worthy of note. VERSTEGAN points out that the animals inhabiting the one side of the Straits of Dover are the same as those on the other side. He supposed that the separation must have occurred since the Deluge, because all beasts were then destroyed but such as were taken into the Ark. "But long after it could not be before the ravenous Woolf

* The Appendix contains references to 307 authors; but these are not all strictly geological.

† Restitution of Decayed Intelligence, in Antiquities concerning the most noble and renowned English Nation, &c. 4to., Antwerp. Several later editions were published in London.

" had made his kind nature known unto man, and therefore no " man, unless he were mad, would ever transport of that race for " the goodness of that breed, out of the continent into any Isles. " . . . . But our Isle, as is aforesaid, continuing since the " Flood fastened by nature to the great continent, these wicked " beasts did of themselves pass over."

During the pre-geological era there were occasional notices of fossils which excited curious wonder in the observers. DR. HATLEY* describes some "formed stones" which occurred in the "Wild of Kent," his specimen being a block of the well-known Paludina Limestone. HATLEY thought them stones, "but," says he, "by what means they receive their likeness to shells is hard " to determine. . . ."

THE REV. J. BROME noticed the Gault fossils at Folkestone; particularly the Ammonites, which he describes as stones "wreath'd " and intorted like screws of smaller and larger dimensions. . . ." " . . . they are by no means petrifactions, but natural, and such as " they were always from the Creation, though how they came to " put on such strange and uncommon Figures is a secret not to be " unravelled." Subsequently he suggests the old explanation of their having been left there by the "Ebb of the Deluge."†

The earliest notice with which I am acquainted, which applies also to other parts of England, is that of STUKELEY,‡ who in 1724 published his antiquarian travels over England. He noticed that the hills of Eastern England run in parallel lines, steep on one side, and having only a gentle slope on the other. He is wrong in his bearings as to the Kentish hills, describing them as running north and south, whereas they run east and west. Apparently he had confused their bearings with those of other and similar English hills, or *escarpments*, as we now term them. In speaking of the hills and plains of England generally, he notes that "mountains are steep and abrupt to the west, especially the " north-west, and have a gentle declivity eastward or to the " south-east, and that plains ever descend eastward. I wonder " very much that this remark has never been made." Then follows what is perhaps the earliest theory of the "origin of " escarpments:"—"I see no difficulty to attribute the reason of " it to the rotation of the globe. . . . . now at the time that " the body of the earth was in a mixt state between solid and " fluid, before its present form of land and sea was perfectly " determin'd, the almighty artist gave it its great diurnal motion. " By this means the elevated parts or mountainous tracts, as they " consolidated, whilst yet soft and yielding, flew somewhat west- " ward and spread forth a long declivity to the east; the same " is to be said of the plains, their natural descent trending that " way, and, as I doubt not, of the superfice of the earth below " the ocean."

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* *Phil. Trans.*, 1684, p. 463.
† *Travels over England and Wales*, 1700. pp. 4 and 123. 2nd ed. in 1707.
‡ *Itinerarium Curiosum*, fol. Lond. pp. 4 and 123.

The next publication which we note is one of very great merit. DR. PACKE, in 1737, in a letter to the Royal Society, proposed to construct a new kind of Map of East Kent. This he published, with an explanatory Memoir, in 1743. The title of the Memoir sufficiently explains its object. The author describes, with greater minuteness than any subsequent writer, the physical features of East Kent. The parallel lines of hills and their varying soils are all carefully laid down. DR. PACKE had intended to show these various soils, by colour, on his map; and if this plan had been carried out, his would have been the earliest geological map, at least of this district. Unfortunately he thought that this could not be done "without slubbering the two Colours "into one another, and Confounding the Print."

GILBERT WHITE'S Natural History of Selborne was published in 1789. Several quotations from his work are given at various parts of this Memoir.

The publication of the County Reports by the Board of Agriculture marks an important step in advance. That on Sussex appeared in 1793, those on Kent, Surrey, and Hants in the following year. The maps accompanying these reports only profess to give the distribution of the soils; but in districts such as the Weald, where there is little or no superficial covering, an Agricultural Map is necessarily a Geological Map. These volumes contain a great amount of good geological information, and to these Reports many subsequent writers have been more deeply indebted than their readers are generally aware. The report on Sussex, by the REV. ARTHUR YOUNG, gives a very detailed account of the working of the Purbeck limestones.*

These reports were followed in 1798 by a general work on the Agriculture of the Southern Counties, by W. MARSHALL. The author, combining the facts detailed in the Reports with his own observations, gives a very good account of the physical features of the country, noting the parallel lines of hills (escarpments), and the varying soils of each. He also evidently observed that the different strata pass under each other; and thus he really possessed to some extent a correct geological knowledge of the district.

In tracing the history of Wealden geological inquiry, we are naturally interested in ascertaining the views of WILLIAM SMITH concerning the district. It does not appear that SMITH was acquainted with the Weald until after its structure had been partly worked out by others. His early maps, up to the year 1801, were here incorrect. Dr. FITTON says:—† "One of the chief defects "in all these maps is, that the tract between the North and South "Downs of Kent, Sussex, &c. is erroneous: being coloured, in some "copies, of the same hue with the beds above the chalk; while in

* *See* p. 386. The author of this report is often thought to be ARTHUR YOUNG, the Secretary of the Board of Agriculture; this is a mistake.

† Notes on the History of English Geology. *Phil. Mag.*, ser. 3, vol. ii. p. 48, 1833. See also FAREY, *Phil. Mag.*, vol. xxxv. p. 169, 1810.

" others, although the outcrop of that stratum towards the Wealds " is expressed, the subjacent beds are not detailed."

SMITH's personal acquaintance with the Weald dates from 1809, when he became engineer to the Ouse Navigation. He says, in a letter dated June 30, 1839:—" In searching for stone to build the " locks and bridges, and by various geological excursions, I became " acquainted with the strata, and collected many of the Sussex " fossils, some of which were left unnoticed in my Stratigraphical " System, from scarcely knowing what stratum they belonged to, " and which I think is still dubious in much of the interior of " the Wealds."* PROF. J. PHILLIPS states that from a quarry at Cuckfield,† SMITH obtained " several bones of gigantic dimen- " sions which, with the rest of his collection, were transferred in " 1815 to the British Museum;" also that SMITH inserted the Geology of Sussex on a large county map for his friend MR. ISAAC WATT.

MR. JOHN FAREY was probably the first who rightly understood the general structure of the south-east of England. In 1806 he constructed a section from London to Brighton on a horizontal scale of 1 inch to a mile; which, although incorrect as to details, shows that FAREY truly observed the truncated edges of Chalk, and also the gradual rise of the lowest beds towards a central line, which he rightly places near Hand Cross. This section was the result of " travelling notes " made apparently from the top of the stage coach, and gave occasion for some sneering remarks upon " stage-coach observations."‡ The section was not published, but several MS. copies were made, one of which is in the library of the Geological Society of London. FAREY saw that the chalk and other beds were " originally level and concentric," and that denudation would best account for the form of the ground. The term " denudation" seems to have been first used by FAREY with reference to the Weald. He says, " the examination which I made " in 1805 and 1806, of the south-eastern parts of England, and " the discovery of the *great Southern Denudation* showed the " necessity of introducing a new term for this Geological pheno- " menon, which has been explained in *Dr. Rees's* new Cyclopædia, " article *Denudation*."§

In 1814, MR. FAREY thus again describes his work:‖ " A very " striking feature of the south-eastern Denudation of England, " and which my manuscript Section made in 1806, ... was " in a principal degree intended to show, is the *rise* of the strata " from the vale of the Thames at London, northwards, to a *strata-*

* PHILLIPS's "Memoirs of William Smith, LL.D.," p. 63, 1844.

† Probably that at Whiteman's Green, from which the greater part of DR. MANTELL's Saurian bones were obtained.

‡ *See* BAKEWELL, *Phil. Mag.*, vol. xlii. p. 124, 1813. PLAYFAIR (in the *Edinb. Rev.*, vol. xx. p. 385, 1812,) alludes in rather contemptuous terms to this section.

§ General view of the Agriculture and Minerals of Derbyshire, vol. i. p. 117 (note) of ed. 1815. See also FAREY's Account of the great Derbyshire Denudation *Phil. Trans.*, vol. ci. p. 242, 1811. The articles "Coal" and "Denudation" in REES' Cyclopædia (1819) contain notices of the Weald; both were written by FAREY.

‖ Notes and observations on Mr. Bakewell's Geology. *Phil. Mag.*, vol. xliii. p. 120.

" *ridge*,* line, ranging nearly E. and W., which crosses the " London and Brighton Road at Hand Cross, 35 miles from " London, and the contrary *dip* of the strata from this place to " the sea at Brighton. . . . ."

I have been thus minute in stating MR. FAREY'S opinions, because of the importance of the fact here insisted on; viz., the former extension of superior strata over the lower beds of the Forest Ridge; also because the Weald was probably "the first " denudated tract that was well ascertained," and for this district the term " denudation " was first used.

It appears doubtful to what extent the older writers were prepared to go in admitting the former extension of strata. HUTTON and PLAYFAIR were well acquainted with the fact of denudation, not only in the enormous amount of material carried away from valleys, and in the former extension of land beyond the present coasts,† but in the fact that all sedimentary strata were formed by the destruction of pre-existing rocks. Probably, however, neither of these writers would have ventured upon joining rock masses far over the edges of denuded strata, as in the Weald.

" The Character of Moses established for veracity as an His- " torian " by the REV. J. TOWNSEND, 1813, is a remarkable book. It contains a good deal of original geological information, with some plates of fossils. TOWNSEND was a friend of WILLIAM SMITH, and may have got much information from him and FAREY; but a large part of his book appears to be the result of original research. He describes the Chalk and Greensand ranges with great general accuracy. He also mentions a fruitless trial for coal at Horsham; but this is probably a mistake. (*See* p. 349.)

In 1812, MR. J. MIDDLETON published an " Account of the " British Mineral Strata,"‡ part of which was republished two years later.§ These notes are chiefly remarkable for fixing correctly the position of the Nutfield Fuller's-earth beds, concerning which there was a good deal of doubt a few years later.

The succession given by MIDDLETON is as follows :—

		Feet.
	Beds above the Chalk - - - - -	300
	Chalk - - - - - - - - -	800
[Gault].	Blue marl - - - - - - - -	30
[L. G. S.]	Fuller's Earth Sand, or Reigate Sand - -	413
[Weald C.]	Weald Measures - - - - - - -	457
		2,000

* In the same paper FAREY speaks of a " *strata-trough* line," corresponding to the modern term of " synclinal line," as " strata-ridge " corresponds to " anticlinal."

† *See* especially on this point, HUTTON'S *Theory of the Earth*, vol. ii. p. 284. The following extract, from p. 289 of the same volume, perhaps bears more directly upon the question before us :—" Though there are in many places immense masses " of strata cut off abruptly, and exposed to view, without the remainder appearing, " we cannot from hence form any estimate of the general quantity of destruction; " at the same time, it must be evident, from a general inspection, that there has " been an immense quantity removed; and that an immense time had been required " in bringing about those revolutions of things, which are not done by violent ' changes, but by slow degrees."

‡ *Monthly Mag.*, vol. xxxiv. p. 393.

§ In MANNING and BRAY'S *History of Surrey*, Appendix to vol. iii., p. lxxix.

The beds of Firestone, &c. at Merstham are here included in the Chalk. This appears to be the earliest notice in which the word "Weald" is used as a name for rocks; thus anticipating MR. CONYBEARE, who proposed the term "Weald Clay" for the beds next below the Lower Greensand, which WILLIAM SMITH had called "Oak Tree Clay." SMITH's term was good enough if it had been used consistently; but, unfortuately, it had also been used for Kimeridge Clay; and, in his "Memoir," SMITH appears sometimes to consider the Gault as Oak Tree Clay.* In this work, published in 1815, three years after MIDDLETON's paper, SMITH gives the general succession as follows:—

	Chalk { Upper, soft, containing flints. Lower, hard, containing no flints.
[U. G. S.]	Greensand parallel to the Chalk.
[Gault.]	Blue Marl.
[L. G. S.]	Kentish Rag, Purbeck Stone, Portland Rock, and Limestone of the Vales of Pickering and Aylesbury.
[Weald C.]	Oak Tree Clay.
[Hast. Beds.]	Iron Sand and Carstone. In Surrey and Bedfordshire contains Fuller's Earth, and in some places Ochre and Glass sand.

Here the Fuller's-earth of Surrey is put with the lowest beds, below the Oak Tree Clay; but in SMITH's County Map, published in 1819, the whole series is correctly given, and the Fullers-earth is placed with the Sands between the Gault and Oak the Tree Clay.†

By MR. WEBSTER's paper, published in 1821,‡ the succession of the beds again becomes involved in doubt; but MR. W. PHILLIPS examined the district in 1821, and finally settled the position of these beds by showing that "the Fuller's-earth is enclosed in and "subordinate to the [Lower] Greensand formation."§ After this date there was no further controversy as to the general position of this Fuller's-earth; but it is not a little remarkable that its *exact* position in the Lower Greensand series is still a matter of dispute.

DR. FITTON,‖ placed it with his lowest division [Hythe Beds]. On the Survey Maps, and in this Memoir (p. 131), it is placed with the Sandgate Beds, whilst MR. MEYER¶ refers it to the lower part of the Folkestone Beds.

In 1822 CONYBEARE and PHILLIPS published their "Outlines "of the Geology of England and Wales," which contains an excellent account of the Wealden district, the first systematic geo-

* Memoir to the Map and Delineation of the Strata of England and Wales, ... 1815. SMITH, always having his eyes open to the agricultural character of rocks, may have been misled by the great luxuriance with which the oak grows on a Gault clay soil.

† In the same year (1819) SMITH published a "Section of the Country from "London to Brighton." The year 1819 is also noteworthy as being that in which DR. MANTELL first published upon Geology. Two articles appeared in the "Gleaner's Portfolio," but the third, which was to have completed the essay, seems not to have been published.

‡ On the Geognostic Situation of the Reygate Stone, and of the Fuller's Earth at Nutfield." *Trans. Geol. Soc.*, ser. 1, vol. v. p. 353 (read May 1819).

§ "*Outlines*," 1822, p. 152.

‖ *Trans. Geol. Soc.*, ser. 2, vol. iv. p. 141, Plate X[a], fig. 3, and Map on Plate VII. *See* foot-note on p. 131 of this Memoir.

¶ "Notes on the Correlation of the Cretaceous Rocks of the South-east and West "of England." *Geol. Mag.*, vol. iii. p. 15, 1866.

logical description of that area. In this work the "Iron Sand" was shown to be quite distinct from the "Greensand," the intermediate bed of clay being here first called *Weald Clay*. The whole of the Cretaceous series was still regarded as marine; "it should be "noticed, however, that the Vivipara [*Paludina*], a fluviatile shell, "has been supposed to occur in the Weald Clay; but the identifi-"cation of the species cannot be considered as complete" (pp. 120, 134). The limestone beds near Battle were referred to the Purbecks (p. 145).

The firestone beds of Merstham are shown to be distinct from the "Greensand," being separated therefrom by a "blue marle" (p. 152); which is doubtfully referred to the "Cambridgeshire "Galt" (p. 126).

The succession of beds in Kent and Surrey were thus completely known to CONYBEARE and PHILLIPS, although the nomenclature differs somewhat from that now employed. The beds above the [Lower] "Green Sand" are vaguely spoken of as the "Chalk Marle," which therefore includes both Gault and Upper Greensand. These authors were less fortunate in their descriptions of the Lower Cretaceous Beds north of the London Basin; some of the Lower Greensand, as at Woburn, was still retained in the "Iron Sand."

DR. MANTELL'S work on the "Fossils of the South Downs," published in 1822, drew the attention of geologists to the Wealden rocks, but it seems doubtful to what extent DR. MANTELL himself was prepared to accept the freshwater origin of so large a mass of strata. He described the land reptiles, whose remains occur so abundantly in various parts of the Weald, and he first recognised the fact that the beds of this district were of exceptional interest; but the fluviatile origin of the beds was not clearly stated. DR. MANTELL appears to have considered his "Tilgate Beds" as something unusual, and perhaps of freshwater origin; but he did not then know that "Tilgate stone" and the Saurian remains which he believes to be specially characteristic of the "Tilgate Beds," occurred at several distinct horizons. He says: —"As these strata are of inconsiderable extent, and hold an "intermediate situation between the Iron Sand and the Weald "Clay, appearing to repose upon the former, it seems probable "that they are either a local deposition, formed in an excavation "or basin of that deposit; or a protrusion of the Purbeck beds, "which lie beneath it." *

The shells in the limestone beds of Ashburnham, Framfield, &c. are described as *Tellina*, and in a note on p. 33, DR. MANTELL states that MR. G. B. SOWERBY thought that some specimens "resembled the *Nuculæ*, but other circumstances led him to con-"sider it probable that they might belong to the genus *Cyrēnē*, the "important question whether they are of marine or of freshwater "origin, is therefore still undecided."

* Fossils of the South Downs, or Illustrations of the Geology of Sussex. 4to. Lond., pp. 37 and 299.

The following remarks by MR. SOWERBY were published in 1812:—"In the Sussex marble also there are other casts of the "same genus [Vivipara], and the late General Davies, in 1806, "brought me similar ones, found two feet under clay, on the "road from Rathersden [Bethersden] to Ashford in Kent. Mr. "Smith informs me that the clay there is beneath the chalk. "From these different localities of shells, apparently of the "same genus, we must conclude, either that analogy is not suffi-"cient to prove that these fossils are of freshwater origin, or else "that there are more freshwater formations than are generally supposed."*

It is to DR. FITTON that we must look as the first to recognise fully and completely that the strata of the Weald were of freshwater origin. In the paper published in 1824,† in which he first proposes the term "Hastings-sand," DR. FITTON gives a short list of fossils from the Wealden Beds of Sussex and the Isle of Wight, and then he adds: "A comparison even of this short list "with that of the Green-sand fossils, points out a distinction be-"tween the latter formation, and the Hastings-sands, which may, "perhaps, deserve attention in the grouping and arrangement of "the strata: the organized productions of the former, so far as we "are acquainted with them, being all marine, but those of the "latter, almost exclusively, of freshwater origin. And, in fact, if "a line be drawn between the Green-sand and the Weald-clay, "the whole series from thence downward to the Portland lime-"stone, may be regarded as one great suite of freshwater forma-"tion:—with the exception principally of those beds of oysters "which occur in small proportion in the Weald-clay, and more "remarkably about the middle of the Purbeck strata . . . ."‡

It was in this paper that DR. FITTON cleared away the difficulties which attended the correlation of the Lower Cretaceous beds in the south-east of England generally, finally separating the Upper from the Lower Greensand, and the latter from the Hastings Beds. So far as the Weald is concerned, this result had been attained by CONYBEARE and PHILLIPS in 1822.

SIR RODERICK MURCHISON'S earliest geological memoir was that on West Sussex, read before the Geological Society in December 1825, and published in 1826. In this paper the structure of the western end of the Weald was clearly explained, and here, probably, the term "Upper Greensand" was first used.

MR. MARTIN'S earliest paper was read to the Geological Society, in March 1827. It was printed in abstract in the Proceedings of the society, but the paper itself was afterwards published by

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* *Mineral Conchology*, vol. i. p. 76.

† "Inquiries respecting the Geological relations of the Beds between the Chalk "and the Purbeck Limestone in the South-east of England." *Ann. Philos.*, ser. 2, vol. viii. p. 379.

‡ MR. WEBSTER, writing in 1811, remarked that the Purbeck Beds may have been deposited in fresh water, and he refers to WOODWARD as suggesting (so early as 1702), that the shells in the Sussex Marble (*Paludina*) resembled freshwater species. (*See* WEBSTER'S letters in SIR H. ENGLEFIELD'S Isle of Wight, 1816.)

the author as a separate work.* MR. MARTIN in this work filled up the gap left between the eastern part of Sussex explored by DR. MANTELL, and the extreme west of Sussex surveyed by SIR R. MURCHISON. MR. MARTIN adopts the term *Upper Greensand*, but he restricts it to the green marly sand which lies immediately below the Chalk and above the Malm Rock. The Sand and the Malm Rock he classes together under the term "Firestone" in the abstract paper, and "Malm" in the later work. The term "Lower Greensand" he restricts to the lower part of that formation, the whole of which he calls "Shanklin Sands." What we now term Folkestone Beds he described as "Ferruginous Sands."

It is unnecessary to follow further the history of Wealden stratigraphical geology. The divisions, excepting those of the Hastings Beds, were in 1829 established as we accept them now, and later work has been chiefly in matters of detail. MR. GODWIN-AUSTEN in 1843 drew attention to the marine clays which occur at the base of the Lower Greensand, and identified them with the "Neocomian" of the continent.† DR. FITTON applied the name "Atherfield Clay" to this bed in the Isle of Wight;‡ which term has been adopted by the Geological Survey, including under it all the beds, whether clay or calcareous concretionary beds, which occur between the base of the Hythe Beds and the top of the Wealden.

MR. F. DREW's paper on the northern part of the Hastings Beds area, giving the result of the Geological Survey work in that district, was published in 1861.§ In this paper the names of the sub-division adopted by the Survey were first proposed.

MR. A. TYLOR, in 1862,‖ described some footprints seen at Hastings; and in doing so he gave a section of the coast from Beachy Head to Folkestone, which is noteworthy as placing the sands upon which Pevensey is built with the Wealden Beds; all previous writer, DR. FITTON included, having taken them as Lower Greensand.

There is one subject upon which a few further remarks may perhaps be made. Much confusion has arisen with regard to the term "Ashburnham Beds," and the position which they hold in the series. The following notes may be useful in this matter.

DR. MANTELL in 1822,¶ and in subsequent writings—down to and including his "South-east of England" (1833)—considered the limestone beds of Poundsford and Archer Wood to be the same as the bed of shelly limestone which occurs at the base of the Wadhurst Clay. Wherever this shelly bed occurred he noted "Ashburnham Beds." This view of the case however presented

* Geological Memoir on a part of Western Sussex, 4to. Lond. 1829.

† *Proc. Geol. Soc.*, vol. iv. p. 171.

‡ *Quart. Journ. Geol. Soc.*, vol. iii. p. 296.

§ *Ibid*, vol. xvii. p. 271. The first sheet of the Geological Survey Map (Sheet 8) on which these names were used, was published in 1863. MR. DREW's memoir on Sheet 4 was published in 1864.

‖ *Ibid.*, vol. xviii. p. 247.

¶ *Fossils of the South Downs.* 4to. Lond., pp. 30–34.

considerable difficulties, and DR. MANTELL saw that in some places his so-called "Ashburnham Beds,"—which he knew to be the lowest in the Wealden district—alternated with beds higher in the series; and he adds, "in the present imperfect state of "our knowledge, it may indeed be disputed, whether these beds "alternate with the ferruginous sand, are situated in a hollow or "basin of that deposit, or form a protrusion or hillock of the "Purbeck lime-stone."

In his note on the "Iron-sand Formation of Sussex," (1826) DR. MANTELL suggests that the Ashburnham limestones may, perhaps, be ranked with the Purbecks.* It is, however, not very easy to determine what DR. MANTELL's opinions on this point really were. In 1844 he writes:—"The Purbeck Strata are obscurely "seen in some of the deepest valleys of Eastern Sussex";† but in 1854, in alluding to the suggestion of EDWARD FORBES, that the beds near Battle are Purbeck, DR. MANTELL remarks:—"There "does not appear to me any satisfactory proof that this supposition "is correct."‡

CONYBEARE and PHILLIPS regarded the limestone beds near Battle as the lowest strata of the district, and they remark:—"This argillo-calcareous formation will probably be found, on "an attentive examination of all its beds, especially the lowest, "to coincide with that of the Purbeck . . . . . ; the upper beds "are, however, said to present different fossils."§

DR. FITTON, whose little work on the Geology of Hastings was published in 1833,‖ pointed out that the limestone beds of Rounden Wood, &c. could not be the same as those described by DR. MANTELL at Ashburnham [Wadhurst Clay], but must lie far below them, and in the section appended to that work they are coloured as Purbecks. In his great paper, published in 1839, DR. FITTON speaks of the former beds as Purbecks.¶

SIR H. DE LA BECHE in 1833 suggested that the Ashburnham Beds might be Purbeck; ** and the same thing has been shown in the map which has illustrated SIR CHAS. LYELL's description of the Weald in the various editions of his works.†† MR. J. TRIMMER also classed the Ashburnham Beds with the Purbecks.‡‡ PROF. EDWARD FORBES, in the abstract of his paper read before the British Association in 1850, says, of the Wealden fossils in the Museum of the Geological Society:—"Some other forms, recorded "as Wealden, but so far as the author has observed, peculiar to "the upper Purbecks, and occupying only a limited horizon in that

* *Geol. Trans.*, ser. 2, vol. ii. p. 131.
† *Medals of Creation*, 1st ed., p. 35.
‡ *Geological Excursions round the Isle of Wight*, 3rd ed., p. 334.
§ *Outlines*, p. 148, 1822.
‖ The same year as DR. MANTELL's *South-east of England*; but before it, for DR. MANTELL refers to DR. FITTON's book.
¶ *Trans. Geol. Soc.*, ser. 2., vol. iv. p. 323.
** *Manual of Geology*, 3rd ed., p. 305.
†† See *The Elements of Geology*, 6th ed., p. 356, and earlier editions.
‡‡ *Practical Geology and Mineralogy*, p. 311, 1841.

" part of the series, are derived from certain anomalous strata " near Tunbridge Wells, which the author believes will prove, " on close examination and accurate survey, to be Purbeck strata, " brought up among the Wealden Clays by faults."*

MR. GODWIN-AUSTEN, in his address to the Geological section of the British Association at Brighton, speaks of the Ashburnham Beds as " the equivalent of the Purbeck Beds of Dorsetshire."†

There is thus abundant authority for separating the lowest strata of Sussex from the Hastings Beds and classing them with the Purbecks. Still better evidence is afforded by the discovery, in the Sub-Wealden Boring, of thick beds of gypsum, a mineral unknown in the Wealden Beds, but occurring in some quantity in the Purbecks.

Papers on the Structure and Denudation of the District.

Some notice of the opinions of early writers upon the subject have already been given in the foregoing pages.

It does not appear that in the discussions on denudation which took place early in this century between the followers and opponents of HUTTON, the Weald was at all alluded to. The earliest systematic description of the district was by MR. CONYBEARE,‡ and here we find the relations of the longitudinal and transverse valleys well pointed out; it is held that it is impossible to imagine these valleys to have been excavated by sub-aerial agencies.

Nine years later MR. CONYBEARE again wrote upon the Weald, and as his remarks of this date are probably less generally known than those of 1822, I reprint the later passage. In this paper MR. CONYBEARE speaks of the upholders of sub-aerial denudation as " Fluvialists," those who advocate great rushes of water are " Diluvialists." Of the Weald he says:—" Now it is, I think, " quite inconceivable that fluviatile erosion could possibly have " produced such a configuration, unless we suppose that the surface " originally, where the drainage commenced its work, presented " uniform slopes from the central axis to the æstuary of the " Thames on the one side, and the Sea on the other, the inter- " mediate longitudinal valleys having been thus filled up; and " that while the direct drainage excavated the transverse valleys, " the lateral drainage excavated the longitudinal valleys: in which " case I would ask, first, why has the lateral drainage produced " so much more considerable effects than the direct drainage? " and, secondly, how has it happened that the lateral drainage " into so many distinct main channels has coincided so as to " form one uniform longitudinal valley, instead of ramifications

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* *Brit. Assoc. Rep.* for 1850. Trans. sect., p. 79 (1851).

† *Ibid*, for 1872. Trans. sect., p. 92, (1873).

‡ In CONYBEARE and PHILLIPS's *Outlines*, 8vo., 1822, Book II., Chap. II., and Introduction, p. xxvii. All the notes relating to the physical structure of the Weald appear to have been written by MR. CONYBEARE.

" extending from one principal stream without any relation to " those of the next principal stream?"*

In 1825 DR. BUCKLAND described the Weald, the valley of Kingsclere and similar areas, and proposed to call them "*valleys* " *of elevation*."† He held that it was impossible by denudation alone to account for the structure of these districts; but that we must explain it by the elevation and fracture of the area modified by subsequent "diluvial denudation."

In the same year MR. G. P. SCROPE published his work on Volcanoes, in which he also describes the Weald. He too refers much to the original upheaval of the district, and proposes to call such areas as the Weald "*valleys of elevation and subsidence*, or " *anticlinal valleys*." He also thought that some part of the apparent denudation might be accounted for by the slipping of the hard beds over the clay in the direction of the dip during the elevation.‡ But he also adds—and, remembering that this account of the Weald was written in 1825, it is particularly worthy of note—such valleys may have been "subsequently enlarged and " otherwise modified; and many others, perhaps indeed a far " greater number, wholly and entirely excavated by the slow " but constant and powerful action of the same causes which are " still continually in force; amongst which the fall of water from " the sky, and its abrasive power as it flows over the surface of " the land from a higher to a lower level, is the principal."

In MR. MARTIN'S description of Western Sussex, we first find stated the important fact that the transverse valleys through the Chalk upon the north side of the Weald correspond to others upon the south side.§ He, however, does not sufficiently distinguish between valleys which only partly breach the Chalk escarpment at a "pass," and those main river valleys by which the escarpment is entirely cut through. Thus, he considers that the long dry valley north of Merstham (Smitham Bottom) corresponds to the river valley of the Adur, whilst the dry valley in which Finden stands is placed opposite the valley of the Mole.

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* "An Examination of those Phænomena of Geology which seem to bear most "directly on theoretical speculations." *Phil. Mag.*, ser. 2, vol. ix. p. 263. The supposition here required is that which PROF. RAMSAY has made in his "plain of " marine denudation"; to the second objection it may be answered that, although the "longitudinal valley," say, of the Weald Clay, is generally spoken of as one valley, it really belongs to several (*see* COL. GREENWOOD'S *Rain and Rivers*, 2nd ed., p. 58).

† *Trans. Geol. Soc.*, ser. 2, vol. ii. p. 119 (published in 1826).

‡ "Considerations on Volcanoes," 8vo, Lond., 1825, p. 213. It should be remembered that geologists of that date were in the habit of constructing (and reasoning upon) imaginary sections, with the vertical scale, and consequently the dip, enormously exaggerated. SIR CHARLES LYELL pointed out the fallacy of this method in his remarks upon DR. BUCKLAND'S paper; *Principles of Geology*, vol. iii., 1st ed., 1833. It is needlees for me to refer to the great part which MR. SCROPE has taken in establishing the theory of subaerial denudation. An extract from an anonymous article by him is given on p. 25.

§ "A Geological Memoir on a part of Western Sussex; with some observations " upon Chalk-basins, the Weald denudation, and Outliers-by-protrusion." 4to, Lond., 1829, p. 52. The term "outlier-by-protrusion" is made equivalent to the modern term "inlier," save that the former can only be applied to an anticlinal area, whereas inliers may be exposed by denudation alone, without any change of dip.

These transverse valleys MR. MARTIN considers to have been formed by transverse fissures during the upheaval of the district, the whole area being subsequently modified by diluvial action. In numerous later papers MR. MARTIN maintained substantially the same views; he, however, afterwards dwelt in greater detail upon the drift deposits of the Weald, which he attempted to divide into four distinct zones.* In his latest paper he says:—
"For as much as I have here and in my former essays endea-
"voured to expound, I rest in the conclusions, that Elevation and
"Denudation have gone hand in hand; that there is a totality in
"the denudations of this part of our island that bespeaks their
"synchronism; and that the agencies of these changes have been
"of the most violent character."†

MR. W. HOPKINS'S paper "On the Geological Structure of the "Wealden District, and of the Bas Boulonnais," was read before the Geological Society in Feb. 1841.‡ The author had entered into a detailed examination of this district in order to test the truth of certain conclusions at which he had arrived upon purely theoretical considerations.§ He traced the chief lines of elevation and disturbance, and maintained that the results of his investigation fully accorded with his theoretical deductions. The *original* upheaval of the district was believed to have been sudden; the force acting "*simultaneously* throughout the disturbed area, with "an *intensity* which might approximate to uniformity for large "portions of that area, while it might be greater at particular "points of it." This original movement "was sufficient to im-
"press upon the district its most distinctive and characteristic
"features, as far as they depend on its geological elevation;" but MR. HOPKINS adds, "while we are compelled, as I conceive, to
"recognise the decisive movement above described, considera-
"tions connected with the denudation of the district equally con-
"strain us to recognise in it the slow process of continental
"elevation."

MR. HOPKINS supposed that as the result of this primary movement, if of uniform force, there would be formed a set of parallel longitudinal fissures, with transverse fissures at right angles to these at the points of intersection. But inasmuch as the force was not uniform throughout the district, the resulting fissures would depart in a corresponding degree from the true direction. The anticlinal lines, flexures, and faults, were supposed to correspond to the longitudinal fissures, whilst the transverse valleys in like manner agree with the transverse fissures. The fissures have determined the positions of the valleys and facilitated their formation by aqueous agency (p. 14).

There is very little in this paper bearing directly upon the question of denudation, but in his anniversary address to the

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* *Phil. Mag.*, ser. 4, vol. ii., 1851.
† *Ibid.*, vol. xiii., 1857.
‡ *Trans. Geol. Soc.*, ser. 2, vol. vii. p. 1 (published in 1845).
§ *Trans. Camb. Phil. Soc.*, vol. vi. p. 1; and *Phil. Trans.*, vol. cxxix. p. 381.

Geological Society in 1852, MR. HOPKINS generally endorses SIR R. MURCHISON'S views (to which I shall immediately allude), and he adds:—"I conceive that by a repetition of such [powerful] "action, not necessarily of any great intensity, the denudation of "the district was probably much assisted, while a very large pro-"portion of the transported matter was finally carried off in the "form of fine sediment by the ordinary action of the sea."*

SIR R. MURCHISON, in 1851, gave a detailed account of the superficial deposits within the Weald, particularly pointing out that all the remains discovered in them are exclusively terrestrial, and that there is a total absence of rounded pebbles along the bases of the escarpments. The drift deposits within the Weald were regarded as representing only the "last great surface opera-"tions." Referring to MR. HOPKINS'S views, SIR R. MURCHISON says:—"Admitting that the region may have been first mainly "denuded by the powerful operations to which he adverts, my "object in this memoir is to show, that at a period long subsequent "and approaching much nearer to the present time, when the "Weald had assumed its present general configuration, and was "to a great extent inhabited by large quadrupeds, there took place "other dislocations of so decisive a character, that masses of "detritus of the Tertiary rocks, Chalk, and Greensand were cast "off and deposited at various altitudes, around the central nucleus, "in the fissures of the Chalk or on its outward slopes."†

In the last edition of "Siluria," SIR R. MURCHISON, in discussing the general questions of denudation, again referred to the Weald; and he remarks:—‡ "I therefore believe that, during "the several upheavals (for I am no believer in one such move-"ment) which took place, by which the central dome was raised, "the present valley was subjected to powerful and perhaps long-"continued currents of water, purging the surface of all those vast "mounds of débris which must have encumbered it after each "upheaving dislocation of the central Wealden axis." The small amount of gravel occurring in the central country he allows may be due to river-action. "Doubtless the present softly-rounded "outlines of these beautiful Chalk hills are due to diurnal ero-"sion by atmospheric agency during long ages, and some amount "of unworn and frost-broken flints is due to this cause."

The "marine theory" of denudation, which has been accepted by the great majority of geologists for thirty years, was first fully stated in 1833 by SIR CHARLES LYELL in his description of the Weald.§ DR. MANTELL‖ in the previous year had advanced

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* *Quart. Journ. Geol. Soc.*, vol. viii. p. liv.

† *Quart. Journ. Geol. Soc.*, vol. vii. p. 387.

‡ *Siluria*, 4th ed., 1867, p. 494. (The so-called 5th ed., issued in 1872 after the author's death, is merely the 4th ed. with a new title page, and having the map and plates bound separately.)

§ *Principles of Geology*, vol. iii., Chaps. xxi., xxii.

‖ "A Notice of the Geology of the Environs of Tunbridge Wells," in BRITTON'S *Descriptive Sketches of Tunbridge Wells.*

the same views, though less fully worked out. He refers to the 3rd volume of the "Principles of Geology," then in the press, for further information on the subject, and we may therefore still regard SIR CHARLES LYELL as the author of this theory, although its publication was partly anticipated by DR. MANTELL.* The following extracts will fully describe DR. MANTELL'S views:—
" The hills and vales around the Wells have been produced by
" the displacement which the strata have suffered during their
" emersion from the depths of the waters. This elevation was in
" all probability not sudden, but gradual; and in the changes
" here contemplated, some of the highest peaks would first appear
" above the waves, and constitute a group of islands. . . . . .
" During this process valleys would be scooped out by currents,
" the sharp edges of the rocks rounded by diluvial action. . . . .
" . . . That romantic spot, the *High Rocks* . . . . . is mani-
" festly an ancient shore—a line of cliffs that for ages bore the
" brunt of the waves, when the valleys of the Weald were filled
" by the waters of the ocean, and the forest ridge was an island
" in an exclusive archipelago. In many other parts of the country,
" the escarpment of the sandstone presents a similar appearance."

In the following year (1833) DR. MANTELL published his "Geology of the South-east of England," in which the gradual upheaval of the district and the successive paring-off of the strata were described (p. 345–352). He does not however ascribe the denudation wholly to ordinary marine action, but still adheres in part to diluvial agency. DR. MANTELL regards the transverse valleys as having been formed *after* the longitudinal valleys; he says:—" The waters resulting from the drainage of the land, and
" which, before the existence of the transverse fractures, probably
" flowed through the longitudinal valleys towards the east, would
" be thrown into different channels, and find their way to the ocean
" by the existing river courses." Of these transverse valleys he says:—" Although these valleys are now river courses, yet it is
" obvious that they originated in disruption, for the strata, in
" every instance which I have observed, diverge from the line of
" fracture."†

DR. FITTON'S little book on the Geology of Hastings was likewise published in 1833. Neither this nor any other of DR. FITTON'S works contains much of interest on this subject. It is remarkable, however, for attributing a greater power to subaërial agencies than geologists were then wont to do. DR. FITTON regards the upheaval and erosion of the beds as having been of a violent character, then he adds:—" Since the disclosure of the land

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* SIR CHAS. LYELL speaks of "the delivery of a course of lectures in May and
" June 1832, at King's College, London, on which occasion I had an opportunity of
" communicating to the scientific world a great part of the views now explained in
" my last [third] volume." (*Principles of Geology*, Preface to vol. iii. p. xviii.)

† *See also* DR. MANTELL'S "Catalogue" of his Museum (p. 7 of ed. 1834) for notes on the Denudation of the Weald.

" thus broken up, the surface appears to have been comparatively " undisturbed :—but it has been cut into by torrents,—worn away " by the incessant action of rains and frost,—and, finally, its " asperities softened down by the effects of vegetation;—and " thus it has been gradually moulded into the forms which we " now behold." (p. 83).

SIR CHAS. LYELL, in the 1st ed. of his " Principles," and in later works, relies much upon the presumed resemblance of the Chalk escarpment to a line of cliff. Speaking of the view from the Devil's Dyke, looking westward, he says:*—" The geologist cannot fail " to recognise in this view the exact likeness to a sea-cliff, and if " he turns and looks in an opposite direction, or eastward, towards " Beachy Head, he will see the same line of height prolonged. " Even those who are not accustomed to speculate on the former " changes which the surface has undergone, may fancy the broad " and level plain to resemble the flat sands which were laid dry " by the receding tide, and the different projecting masses of Chalk " to be the headlands of a coast which separated the different " bays from each other." The denudation was effected during upheaval, the lower beds being successively brought within reach of the waves; hence the reason " why no wreck of the chalk should " occur at great distances from the chalk escarpments. For it is " evident that where the ruins of the uppermost bed had been " thrown down upon the surface of the bed immediately below, " these ruins would subsequently be carried away when this in- " ferior stratum itself was destroyed. And in proportion to the " number and thickness of the groups, thus removed in succession, " is the probability lessened of our finding any remnants of the " highest group strewed over the bared surface of the lowest."†

The transverse valleys were supposed to owe their origin to fracture, aided, possibly, by an anticlinal dip on both sides of the valley. " In whatever manner the transverse gorges originated, " they must evidently have formed ready channels of communica- " tion between the submarine longitudinal valleys and those deep " parts of the sea wherein we imagine the tertiary strata to have " been accumulated. If the strips of land which first rose had been " unbroken, and there had been no free passage through the cross " fractures, the currents would not so easily have drifted away the " materials detached from the wasting cliffs, and it would have " been more difficult to understand how the wreck of the denuded " strata could have been so entirely swept away from the base of " the escarpment."‡

These extracts are taken from the 1st edition of the " Principles of Geology," and sufficiently indicate the views of their author, which were repeated with little modification, and without important addition, in later works. In the last edition of the " Elements" (1865), a greater effect is allowed to subaërial

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* *Principles of Geology*, vol. iii. p. 291, 1st ed. 1833.
† *Ibid*, p. 298. ‡ *Ibid*, p. 302.

agencies in modifying the form of the ground than in earlier editions.*

SIR CHAS. LYELL now allows a still greater power to subaërial agencies, as appears from the following extract from a letter addressed by him to MR. WHITAKER:†—"I have long ago "modified my opinions on denudation, and I now agree with you "in considering that the escarpments round the Weald are not "inland cliffs, as I formerly supposed, although at some points the "sea may have entered through transverse valleys and modified "parts of them."

SIR CHARLES LYELL, in a later work, after giving the arguments in favour of subaërial denudation, as summarized by MR. WHITAKER, says:—"The above theory is by no means incon-"sistent with the opinion that the limits of the outcrop of the "Chalk and Greensand which the escarpments now follow, were "originally determined by marine denudation. When the south-"east of England last emerged from beneath the level of the sea, "it was acted upon, no doubt, by the tide, waves, and currents, "and the Chalk would form from the first a mass projecting "above the more destructible clay called gault. Still the present "escarpments so much resembling sea-cliffs have no doubt, for "reasons above stated, derived their most characteristic features "subsequently to emergence from subaërial waste by rain and "rivers."‡

This brief account of SIR CHARLES LYELL'S views may appropriately be closed with the following extract, from the 1st ed. of the "Principles:"§—"In our attempt to explain the origin of the "valleys in the south-east of England, it will be seen that we refer "their excavation chiefly to the ocean. We are aware that we "cannot generalize these views and apply them to the valleys of "all parts of the world. In Central France, for example, rivers "and land-floods, co-operating with earthquakes, have deeply in-"tersected the lacustrine and volcanic deposits, and have hollowed "out valleys as deep, perhaps, as any in our Weald district. In "what manner these effects may be brought about in the course "of time, by the action of running water, even without the inter-"vention of the sea, may be understood by what we have said of "the removal of rock by aqueous agency during the Calabrian "earthquakes [vol. i. chap. xxiv]."

The first edition of the "Principles of Geology" was reviewed in the Quarterly Review by MR. G. P. SCROPE. This article is remarkable for containing the earliest statement of the subaërial denudation of the Weald. SIR CHARLES LYELL inferred that the Chalk had extended completely over the Weald. MR.

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* *See* pp. 369, 372.

† Quoted by MR. WHITAKER in his paper on Subaërial Denudation; *Geol. Mag.*, vol. iv. p. 449. See also on this point the 10th ed. of the "Principles" (1867), vol. i. pp. 567, 570.

‡ *The Student's Elements of Geology*, 8vo, 1871, p. 81.

§ Vol. iii. p. 319.

SCROPE saw no proof of this, but supposed that the Chalk and Greensands thinned away towards the central district, which "had "been elevated above the sea *before* the deposition of the Chalk, "and formed a ridgy island in that sea." The resulting surface, when upheaved above the sea, would be very much the same as that which PROF. RAMSAY has termed a "plain of marine "denudation."

MR. SCROPE says:—"There does not appear any reason for "introducing the sea into the Weald valley, as Mr. Lyell does, "for the purpose of effecting its denudation, and the removal of "the materials of its ancient strata. The agency of rain and "rivers* acting through an indefinite time may have alone accom-"plished this. And since no traces of marine deposits of the "eocene, or any later age, are met with throughout the whole "basin, we must hesitate to believe that the sea covered it during "any part of the tertiary period."†

MR. S. J. MACKIE in 1860 proposed a modification of the marine theory. He assumed that at the time of the denudation the Straits of Dover were not opened. The flood tide rushed with force up the English Channel, and the waters, barred by the Chalk isthmus, scoured round the Weald.‡

MR. S. V. WOOD, JUN., has published several papers upon the drift deposits and the denudation of the south-east of England.§ He believes that the valley systems of that district are referable to two sets of disturbances. To the earliest movements are due the "series of concentric curves, the ex-"terior of which is formed by the Cotteswold escarpment, and "the next to that by the Chalk escarpment from Pangbourne to "Royston, while the inner ones constitute a series of smaller "escarpments, of which the trumpet-mouthed gorges in the "North Downs [believed by the author to be river-mouths], "successively form part, the whole set centering near Canter-"bury. These curves are connected very distinctly with another, "and apparently contemporaneous set, which centre near the "western extremity of the Isle of Wight, and are concentric half "circles formed by the Lower Tertiary outcrop of Hampshire "and the Chalk escarpments of the south-west. The rectilinear "movements to which the denudation of the Weald valley is "due have destroyed this anterior curvilinear contour, which is "perfect up to the points where those rectilinear upcasts occur."

* Is this the earliest use of the phrase "rain and rivers" in a geological sense?

† *Quarterly Review*, on "LYELL's Principles of Geology," April 1835, p. 440.

‡ *Geologist*, vol. iii. p. 203. We may here note that whilst the ordinary marine theory of denudation is supposed by its advocates to be applicable to escarpments generally, this modification of it is applicable to the Weald alone.

§ The earliest is "On the formation of the River and other valleys of the East of "England," *Phil. Mag.*, ser. 4, vol. xxvii. p. 180, 1864; the latest is, "On the Evi-"dences afforded by the Detrital Beds without and within the North-eastern part of "the Valley of the Weald as to the Mode and Date of the Denudation of that Valley," *Quart. Journ. Geol. Soc.*, vol. xxvii. p. 3, 1871; this is a very important contribution to the subject, and from it the extracts in the text are taken (pp. 14–19). Other papers were published in 1866, 1867, and 1870. (See Appendix I. under those years.)

MR. SEARLES WOOD looks upon all but the newest gravels of the Thames valley and the Weald as marine. The earlier curvilinear movement was "synchronous with the first denudation of the "Tertiaries from the south of England," and with the planing-off of the Chalk over the Weald. The later rectilinear movement was subsequent to the first accumulation of the Thames gravel (which the author regards as marine). The effect of this disturbance was to raise the northern part of Kent above the sea, and to connect it with France, thus closing the north-eastern part of the English Channel, and "giving rise thereby to a great sub-"marine denudation," by which the escarpments were formed. "By this action the inlets [of the sea] in which the Thames and "coeval gravels had accumulated shrank into river-channels, "through which the drainage of Essex and Middlesex flowed "southwards into this disturbed sea [within the Weald]." During this period the Hastings Sand country formed an island or series of islands, between which and the chalk escarpment there would be a considerable tidal scour, largely augmented by the Straits of Dover being closed. "On the other hand, the diminution of "this tidal scour, produced by the opening of the Dover Straits, "supplies an efficient cause why the elevation of the Wealden area "should overmaster the denuding agency, and so extricate the "Weald altogether from the sea." "So soon as by these means "the elevatory action gained on the tidal erosion, and the Weald "was deserted by the sea, the reversal of the drainage of the "Stour and Medway into its present direction commenced." The higher gravels of the Medway are believed to have been formed when the Weald was an inlet of the sea, with rivers flowing *into* it from the north; the lower gravels are regarded as the product of the river after the reversal of drainage, when it flowed to the north *from* the Weald, as at present.

MR. MACKINTOSH is the latest writer who has advocated the ordinary marine theory; not, however, altogether dispensing with more violent agencies. He regards the escarpments as sea-cliffs, and the gravels as of marine origin.*

We have seen that MR. SCROPE in 1835, in accordance with the views of denudation which he had long held as regards Central France and other districts, suggested that the Weald may have been denunded by "rain and rivers." From this time down to the publication of COL. GEORGE GREENWOOD'S work in 1857,† it does not appear that anyone advanced the same views. As an extract from this work is given in the chapter on denudation it is not necessary to dwell much upon it here.‡ We may note, however, the importance of the fact, strongly insisted upon by

* *See* his papers in the *Geological Magazine* for 1866; and his *Scenery of England and Wales*, Part IV., Chaps. iii. and xiii.; 8vo, Lond. 1869.

† Rain and Rivers, or Hutton and Playfair, against Lyell and all comers. 8vo, Lond. 2nd ed. in 1866. COL. GREENWOOD says (preface to 2nd ed.):—"The "doctrines advocated in this book were first published by me in the second edition "of the 'Tree lifter.' Pt. III., 1853."

‡ Chap. xvi., p. 273.

COL. GREENWOOD, that the Weald is really *a hill*, not a valley. It is only the great plain of the Weald Clay, surrounding the central part of the Weald, that can in any sense be described as a valley, and this is not one valley but several.

COL. GREENWOOD revived the arguments of HUTTON and PLAYFAIR upon denudation, and used them with great force in reference to the Weald. But it is at least doubtful how far the seasoning of these writers can be held to be conclusive as it stands in their works. If the Weald, for instance, were upheaved with a dome of chalk extending entirely over the country, and upon this upheaved surface rain and rivers were to act, it is doubtful if the result would be the present system of longitudinal and transverse valleys. To obtain this it is neccessary that the country should be *planed across* so that successive rocks should in turn crop up to the surface. PROF. RAMSAY in 1846 had shown how this must have been the case in South Wales and the west of England, and he also showed that for the explanation of this we must look to the planing action of the sea.* The recognition of this fact is, perhaps, the most important step which has been taken in this question ; for, granted such a plain of marine denudation with a succession of hard and soft rocks cropping up upon it, one can see that long-continued subaërial weathering must result in a system of longitudinal and transverse valleys. PROF. RAMSAY in 1863† again wrote upon the subject; and in 1864‡ he further developed his views with especial reference to the Weald, maintaining that the denudation of the Weald, including the production of the escarpments, was due solely to subaërial agencies acting upon a plain of marine denudation which sloped from the centre of the Weald to the north and south.

The publication of MR. JUKES'S paper "On the mode of Formation of some of the River-valleys in the South of Ireland"§ was an important step in the denudation controversy. It is however worthy of remark that the structure of that country, and its relation to the present valley system, is not that which usually occurs. There we have streams rising in high land, flowing down with the dip, then running along longitudinal valleys, and, finally, turning sharply at right angles to their former course and cutting through hills. But in place of the gorge being through the highest beds of the series, as is usually the case, it is in the lowest, that being brought up again by foldings of the strata. The reason of this is that the Carboniferous Limestone and Lower Limestone Shale are more easily eroded than the Old Red Sand-

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* On the Denudation of South Wales and the adjacent counties of England, *Mem. Geol. Survey*, vol. i. p. 327 ; and *Brit. Assoc. Rep.* for 1847, Trans. sect., p. 66.

† *Phys. Geol. and Geography of Gt. Britain*, 1st ed.

‡ *Ibid*, 2nd ed., p. 80. *See also* the 3rd ed. of this work (1872), in which the subject is more fully discussed ; and "The River-courses of England and Wales," *Quart. Journ. Geol. Soc.*, vol. xxviii., p. 148, 1872.

§ *Quart. Journ. Geol. Soc.*, vol. xviii. p. 378, 1862.

stone; hence the former has been scooped out into longitudinal valleys, lying in synclinal lines, whilst the latter stands out as ridges; through which, on the one hand, the streams flow, and in which, on the other hand, the streams rise.

The following reference to the Weald occurs in a Postscript to MR. JUKES'S paper:—" Perhaps I may venture to ask the ques-
" tion whether the Chalk, when once bared by marine denudation,
" which perhaps removed it entirely from the centre of this dis-
" trict, has not been largely dissolved by atmospheric action, and
" whether the lateral river-valleys that now escape through
" ravines traversing the ruined walls of Chalk that surround the
" Weald may not be the expression of the former river valleys
" that began to run down the slopes of the Chalk, from the then
" dominant ridge that first appeared as dry land during or after
" the Eocene period?"

MR. GODWIN-AUSTEN'S papers upon the drift deposits of the south and south-east of England do not much discuss the question of denudation. The following extracts, however, bear upon the subject; they refer to the Chalk districts of the north of France, but are equally applicable to much of the Chalk of England.*

" Over the whole of the chalk-area here described, the upper
" tabular surfaces are covered with the accumulation of Flint-
" drift . . . . . , as a general rule, the heights are covered with
" gravel, and the valleys are free. . . . . It follows then that
" the valley-systems must have been mainly formed since the
" dispersion of the Drift. . . . . .

" From this we may venture on one further inference,—that
" the agent which has produced the greater part of the existing
" valley-systems of the chalk-area of the north of France has
" been merely meteoric.

" The formation of valleys, such as those of the French chalk-
" area, may seem to some to require an agency more powerful
" than that now suggested; but, taking as our guide the quantity
" of lime taken up by every gallon of rain-water which flows from
" our own chalk district, the question becomes one of time, in the
" course of which every line of inequality along which water may
" flow must ultimately be deepened and widened out. . . . . ."

MR. J. PRESTWICH, in his elaborate description of the flint implement-bearing gravels, scarcely refers to the Wealden district, since no flint implements had been recorded from the gravels of that area. But he gives a map showing the distribution and composition of the gravels over the south and east of England and part of France.† As regards the River Medway and its tributaries, the distribution of the gravels, as shown on this map, agrees with that described in this Memoir; each tributary of the river having in its gravels only pebbles of the rocks contained in its basin. But the same fact is also shown to hold good over a larger

* *Quart. Journ. Geol. Soc.*, vol. xi. p. 118, 1855.
† *Phil. Trans.*, vol. cliv., Part II., p. 247, 1864.

area.* It is held that the excavation of the valleys is wholly due to river-action; the gravel represents old river-beds, and the brick-earth or loess the deposits left by the rivers in times of flood. The climate being probably much more severe at the time when the higher gravels were deposited than now, the melting of snow in the spring would raise the river to levels such as they cannot possibly reach now, and the flood deposits would be proportionately increased. The rivers would also be laden with ice, and in this manner MR. PRESTWICH accounts for the large blocks of stones sometimes found in the gravel.

Not the least valuable part of MR. PRESTWICH'S paper is the full account which he gives of river-action now going on in Canada, Siberia, and elsewhere; under conditions such as he assumes to have once prevailed in this area.

MR. A. TYLOR, in 1867, in a paper on the "Amiens Gravel," proposed to explain the great deposits of gravel and brick-earth, by assuming the existence of a "Pluvial Period" during which the rainfall was excessive, and such as now only prevails in tropical climates.† The same opinion was afterwards brought forward by M. BELGRAND,‡ and has been partially adopted by MR. PRESTWICH.§ MR. TYLOR, however, regards the higher and lower gravels as of one and the same age; the excessive rainfall being sufficient to swell the rivers up to the levels of the highest fossiliferous gravels.

The results of the mapping of the Medway gravels by the Geological Survey were submitted to the Geological Society in May 1865.‖ It was contended that the distribution of the gravels was such as could only be explained by fluviatile erosion, and that such erosion could he proved for a depth of 300 feet. As the arguments used in that paper are given at length in the XVIth chapter of this Memoir, they need not be further referred to here.

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* The following remark by the Rev. J. TOWNSEND, published in 1813, is worth repeating here:—" . . . . in every part of the globe, the gravel near to a river " shows, even to a considerable depth, the strata of the country through which all " the tributary streams now pass." "The Character of Moses established for veracity " as an Historian." 4to., p. 229.

† Published in 1868, *Quart. Journ. Geol. Soc.*, vol. xxiv. p. 103; see also MR. TYLOR'S papers on "Quarternary Gravels." *Ibid.* xxv. p. 57, 1869; and that on "Deltas" in the *Geol. Mag.*, vol. ix. pp. 392 and 485, 1872, which is a report in full of a paper read before the Geological Society in 1868. MR. TYLOR'S theory of an excessive rainfall really dates from 1853, when he wrote upon the amount of sediment carried into the sea by rivers and the gradual raising of the sea-level by such means; *Phil. Mag.*, ser. 4, vol. v.

‡ "Le Bassin Parisien aux Âges Antéhistoriques," chap. xiv. 4to., Paris, 1869. A full account of M. BELGRAND'S work was given (by MR. PRESTWICH) in *Nature*, March 14, 1872.

§ Anniversary Address to the Geological Society, Feb. 1872. *Quart. Journ. Geol. Soc.*, vol. xxviii. p. lxviii.

‖ "On the Superficial Deposits of the Valley of the Medway with Remarks on " the Denudation of the Weald;" by DR. C. LE NEVE FOSTER and W. TOPLEY. *Quart. Journ. Geol. Soc.*, vol. xxi. p. 443.

At the same meeting of the Society, MR. PRESTWICH communicated a paper on the Raised Beach of Sangatte, in which he said:—" I have evidence to show that in " the very centre of the Wealden area there are remarkable cases of valley-excava- " tion and old river-action. I have even there found beds of high-level gravel." *Ibid.* p. 441.

PART II.

STRATIGRAPHICAL GEOLOGY.

CHAPTER III.—PURBECK BEDS.

These beds are nowhere seen on the coast, but it is probable that they occur at no great depth below the base of Fairlight Cliff.

The area over which they are exposed extends in a slightly curved line convex to the north, from Whatlington on the east to Tottingworth Farm (1½ miles N.E. of Heathfield) on the west. The length of this area is 10 miles, and its breadth from ¼ to ¾ of a mile. It is not wholly continuous throughout this length, being interrupted by two spurs of Ashdown Sand which connect the great masses of this formation on either side.

The highest ground of this district is formed of Ashdown Sand, brought up by an anticlinal, the course of which is through Tilsmore Wood on the west, along by the north of Heathfield and Brightling, and thence eastwards to the north of Battle. The Purbeck Beds occur along and partly to the north of this line, they are exposed mainly by denudation in the valleys, but are also brought up amongst the higher beds by faults.

The total thickness of the Purbeck Beds exposed in Sussex is about 330 feet.* The greater part consists of shales; the limestone beds occur chiefly on two horizons, an upper one called "Greys," or "Vein Greys," and a lower one called "Blues;" below the latter there are some other limestones only known in Rounden Wood, and hence termed the "Rounden Greys."

	Ft.
Beds above the "Greys" - - - - -	? 30
"Greys" or "Vein Greys" with associated shales -	45
Strata, mostly shales with a few thin limestones -	130
"Blues," with associated shales - - - -	25
Beds below the "Blues" - - - - -	? 100
	330

The space between the Greys and the Blues consists chiefly of shale, but there are also a few beds of limestone. It is only in this part of the series that sandstone occurs; it is very like that found in the Hastings Beds above, if there be any difference the Purbeck sandstone is slightly coarser in grain.

* Lower beds than any hitherto known are found in the Sub-Wealden Boring; but, in order that the latest information may be embodied in this Memoir, I will describe that at the end of this chapter. We may estimate the total thickness of the Purbecks as about 400 feet.

The beds from the Blues upwards, preserve a striking uniformity of character throughout their range. Not only is the general succession always the same, but the characters of the individual beds are often so well sustained that most of the limestones are readily recognised by the workmen wherever they occur.

It is probable that the beds below the Blues are less constant; for the strata pierced in the Sub-Wealden Boring cannot be correlated with those of Rounden Wood, although it is certain that the Rounden Greys, or their representatives, have been passed through. The beds of gypsum found in the bore hole must lie below the Rounden Greys.

The shales of the Purbecks generally are not so very unlike those of the overlying Wealden Beds; but in and near the Greys there are some peculiar tough, dark brown and blackish leathery shales, which when dry somewhat resemble stiff brown paper in character, and occasionally also in colour. They may be seen in most of the waste heaps over the areas in which the Greys have been worked; generally these shales contain large numbers of crushed *Cyrenæ*. There is also a thin bed of shale slightly resembling this above the 8-foot Greys, which overlies the main blue limestone; but this is not nearly so leathery as that in the Greys; it comes out in flattish masses when freshly dug in the pits, but on weathering it goes into small fragments and then contains a good deal of selenite. This shale also contains *Cyrena*.

The water which flows from the old workings of the Greys, and the beds immediately above them, is frequently highly charged with bi-carbonate of lime;* that from the Blues, and the lower beds generally, is far less hard.

The Greys and the beds above them are very fossiliferous, the Blues much less so as a rule; whilst the "Bastard Blues" and the lower beds seem to be almost unfossiliferous. The lowest beds known in Rounden Wood, the "Dunk Shaws," are crowded with *Cypridea* (*Cypris*) *Valdensis*, Sow. The beds between the Blues and the Greys are not much known, but some interesting fossils occur in this position in Limekiln Wood.

None of the characteristic Purbeck Cyprideæ have as yet been discovered in these beds; and the palæontological evidence of their Purbeck age is not very conclusive. They, however, contain some Purbeck forms, which are absent through nearly 2,000 feet of the overlying Wealden strata, and only reappear in the fluvio-marine Punfield Formation. For this reason, and also because of the striking lithological difference between these beds as a whole and the Wealden proper, the lowest strata of Sussex are here described as Purbeck Beds.

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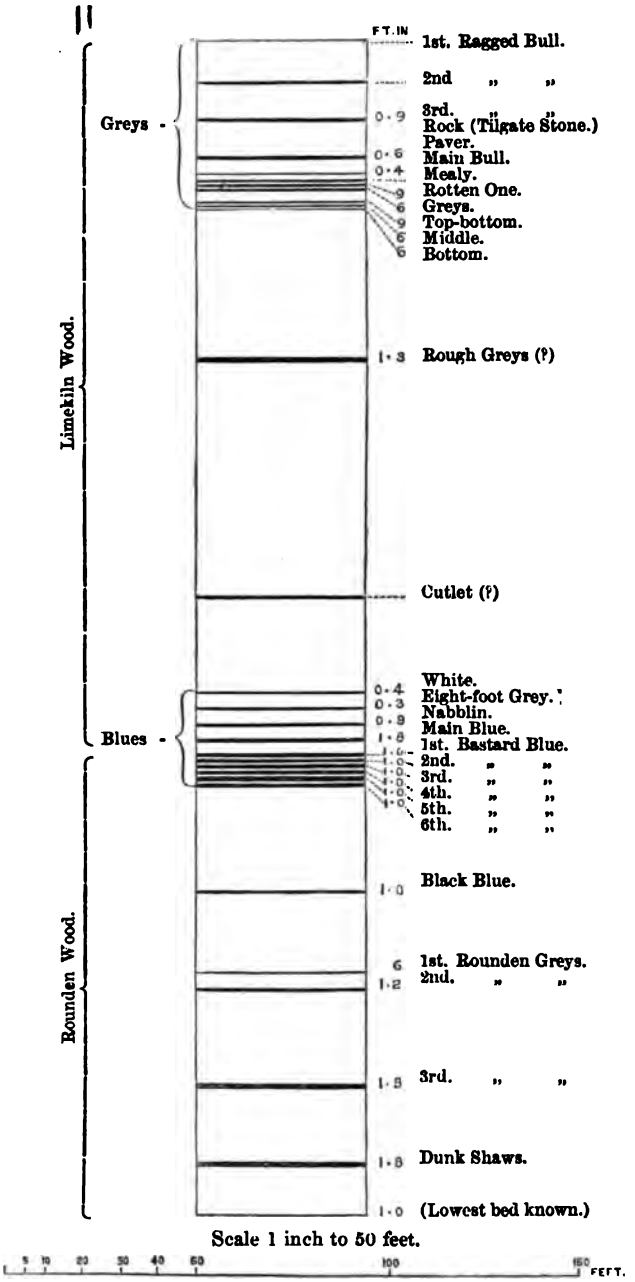
* The "petrifying spring" at Poundsford comes from beds at this horizon. See MANTELL's South-East of England, p. 223; and HUNTER, Mag. Nat. Hist., vol. viii. p. 597, 1835.

Fig. 1. *Vertical Section of the Purbeck Beds in Limekiln and Rounden Woods.*



As the Purbecks of Dorsetshire are themselves variable over comparatively small areas, we can hardly expect to find much similarity between those beds and those of Sussex. But we may note as a point of resemblance of some interest, that in the Dorset-

shire beds the limestones are collected chiefly on two horizons, separated by a considerable thickness of shales, &c., in which comparatively few limestones occur. It is then possible that these may represent the "greys" and the "blues." As a point of difference we may note that *Paludinæ* are somewhat rare in the Sussex Purbecks, whilst they form entire beds in the Dorset series —the well-known Purbeck Marble.

I am not aware of any section which shows the exact junction of the Ashdown Sand with the Purbeck Beds. Perhaps there is no sharply defined line; still the two divisions are well marked off from each other, although in the lower part of the Ashdown Sand there is a good deal of loam and clay, the representative of the Fairlight Clays of the coast.

No *complete* vertical section of the Purbeck Beds has been obtained, and our knowledge is almost confined to the limestones and associated beds that were actually worked. As few sections are now exposed, and the district is much disturbed by faults, it is somewhat difficult to make out the succession. The soil formed by these beds is mostly stiff, as clays and shales predominate in their composition; a great part is woodland, only a small proportion being under the plough. The limestones were very largely wrought formerly, mostly by shafts, but sometimes by open workings.*

The following notes were collected by MR. CHARLES GOULD, from miners, quarrymen, and others, who had been employed in the workings.

Archer Wood.—This is a small wood which lies upon the left-hand side of the road from Battle to John's Cross, at a distance of a little more than a mile from the former place.

Both the grey and the blue limestones are found in it, but the latter are the most abundant, and have alone been worked to any considerable extent.

The works have been abandoned for nearly 40 years. They appear to have been conducted in a very effective manner, and were superintended at the outset by skilled miners from Derbyshire.

Any information which may be collected upon the subject now must necessarily be somewhat imperfect, in consequence of the long interval which has elapsed since the works were abandoned and the death or removal or nearly the whole of the workmen, employed upon them.

I have, however, been furnished with a great many interesting particulars by an intelligent man, who was foreman of the works during the latter part of their existence. I have complete confidence in their general accuracy, having been enabled to test personally the greater part of his statement.

The thickness of the shales intervening between the "Greys" and the "Main Blue" is variously estimated at from 100 to 140 feet, it is certainly not less than the former, insomuch as shafts of that depth sunk down to the "Main Blue" in Archer Wood, failed to pass through any of the "Greys."

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* An account of the old workings is given in Chap. xxiv., p. 384.

Excepting in a few unimportant particulars, the following section agrees with that obtained from Limekiln Wood.

The "Blue limestones" occasionally contained lignite, and crystallized calc spar, known to the miners as "dog's tooth spar." Mr. Cotton also obtained some from the Greys at Copyhold Bridge.

Succession of the Limestones at Archer Wood.

"*Greys*" *proper*, or "*Vein Greys*."				*Vide* notes on Limekiln Wood.
From 100 to 140 feet of dark blue shale with occasional bands of limestone.	*1st White*		In. 4	These are two thin beds lying close together, and described by my informant as presenting an appearance upon fracture very similar to that of Clay Ironstone. He was uncertain whether they lay above or below the 60-foot grey.*
	2nd White		4	
	60-*foot Grey* - 60 feet above the main blue.		2	
	8-*foot Grey*. 8 feet above the main blue.			The Nablin was either absent, or had escaped his recollection.
"*Blues*."	*Main blue*, or 1*st limestone*		In. 20	A clear smooth slate-coloured limestone, homogeneous, and not composed of two distinct layers, as the same bed is at Limekiln Wood.
	Bastard Blue. All these beds are separated from one another by short intervals of shale.	*2nd limestone* -		A thin limestone, sometimes absent.
		3rd limestone -		A good limestone.
		4th limestone -	26	Very flaky. Less so. More or less solid. — Top portion, this was not extracted, but left to form a roof.
				The grizzle - 1½ inches. This was extracted, but instead of being burnt, was sold to be used as paving stone.
		5th limestone	3 or 4	These were got after the above stones had been drawn.
		6th limestone	18	The 6th was the best for lime, except the main blue.
		7th limestone. *8th limestone*.		My informant never saw these stones, but was aware of them by tradition.

* According to information which I have recently obtained from Mr. John Fuller, who was well acquainted with the lime-workings, it seems that the "Whites" occur a short distance above the "8-foot Grey."—W. T.

The Greys are exposed in the road-cutting a little north of Copyhold Bridge. The beds seen here correspond with the section in Limekiln Wood from the shale above the "Paver" to "Bottom."

In some places, as, for instance, at Darvel Beach, there occurs about 1 foot above the paver, a layer of irregular masses of rag about 2 feet thick. This is known by the name of the "Paver rock;" it will not burn into lime, but is an excellent road material.

Limekiln Wood.—This lies to the north of Netherfield Toll, upon the road from Battle to Heathfield. Both the Grey and Blue Limestones are found in it, the former in the higher part of the wood, the latter in the lower ground near the stream. The stone was formerly extensively drawn by means of open workings and bell-pits.

Succession of the Limestones at Limekiln Wood.

A.—"Greys," consisting of:—

Feet.			
10	I.	*First "Ragged Bull."* 6 in. Shale.	3 layers of shelly limestone (sometimes passing into Sand rock), about 10 feet apart.
10	II.	*Second "Ragged Bull."* 4 in. Shale.	
10	III.	*Third "Ragged Bull."* 2 to 8 in. Blue shale, *Tech. "Trooper."*	
4	IV.	*Paver* - - 6 inches Blue shale, *Tech. "Bull Marl."*	A shelly limestone, used for paving.
2½	V.	*Main Bull* - 3 or 4 inches Blue shale or slate. Green bed. Shorks.	A shelly limestone.
1½	VI.	*Mealy* - - - Shale, &c., Tech. *"Rotten one dirt."*	Several layers, varying from 2 to 6 inches. The slate between them shelly.
In. 9 or 10	VII.	*Rotten one* - 8 or 9 inches Blue shale. Tech. *"Grey Bed."*	A shelly limestone.
	VIII.	*Greys* - - 6 inches The top part shelly.	
Ft. 4	IX.	*Top bottom* - 8 or 9 inches *"Brickbats,"* hard, shorky stuff. *"Iron beds."* *"Egg-shell"* beds. Very shelly.	A shelly limestone. This and the "Grey" give the best lime.
In. 14	X.	*Middle* - - 6 inches Shale. Tech. *"Sharbs,"* shelly. 6 inches.	These are not shelly in Limekiln Wood.
Rests upon—	XI.	*Bottom* - - 6 „	

About 40 feet below this come:—

B.—"Rough Greys" - 14 or 15 inches (Not shelly ?)

The "Rough Greys" are said to lay about 100 feet above the Main blue.

C.—" Blues." The " Blues " consist of the following beds :—

Feet.				
24	I.	*Cutlet* - - - -		A hard stone said to resemble the white.*
		Shale.		
		Shale and clay. Tech., " *Top Red Marl.*"	8 feet.	
		Shale, sometimes sandy. " *Top Sand Bed.*"	8 feet.	
		Shale. Whitish dirt.		
4	II.	*White* - -	4 inches.	
		Shale and clay. Tech. " *Bottom Red Marl.*" Occasionally contains lignite and bones.		
	III.	*Eight-foot Grey*	3 inches	Somewhat shelly.
		Blue shale.		
4	IV.	*Nablin* -	8 or 9 inches	No shells.
4		Shale. Tech. " *Blue shorks,*" with a bed in the middle, about 9 inches thick, which occasionally contains bones.†		
	V.	*Main Blue.*		
		Shale.		
3	VI.	*First Bastard Blue.*		These are each about 1 foot thick, and are separated by thin partings of shale. They are all smooth clear limestones, free from grit, and not fossiliferous.
10 ?		*Second Bastard.*		
		Third Bastard.		
		Fourth Bastard.		
		Fifth Bastard.		
		Sixth Bastard.		

Mr. Walter, of John's Cross, informs me that many years ago he sunk a pit, 70 feet deep, at the south end of Limekiln Wood, near Netherfield Toll, in doing which he passed altogether through five layers of limestone (Ragged Bulls), before reaching the Paver.

The section, as well as he can remember, was:—

Feet.		
40	Loam and mould - - -	Slight thickness.
	Clay - - - -	2 or 3 feet.
	1*st Ragged Bull* - - -	A very thin bed.
	" *Trooper* " Blue Shale.	
	2*nd* "	
	3*rd* "	
	4*th* "	
	5*th* "	
30	Paver.	
	Bottom.	

Several pits have been sunk upon Darvel Beach Farm, in a field east of the house, for the purpose of extracting the hard calciferous sandstone which occurs in the upper part of the Greys. In this locality there are two layers of it which are distinguished by the names of the Top and Bottom *rocks*.‡

* " Cutlet " seems to have been a term applied to any bed of inferior limestone, not otherwise named, at whatever horizon it may have occurred.—W.T.

† Probably this is the bed known as the " Iron Bed " :—A hard shale which smells strongly of sulphur when it is worked.—W.T.

‡ For a list of fossils from these beds see Appendix, I., where will also be found a list of fossils from beds on the same horizon at Perch Hill, on the road leading from Brightling Down to Burwash Wheel.—W.T.

The following description of the beds occurring in a pit 30 feet deep was given me by the man who had been employed in sinking it:—

				Inches.
Feet 30		Hazards, a few irregular beds of limestone.		
		Ragged Bull, limestone.		
	Feet 8 or 10	TOP ROCK - -	Calcareous Sandstone -	8 or 9
		parting 5 feet.		
		Bull, limestone.		
		parting 2 or 3 feet.		
		BOTTOM ROCK -	Calcareous Sandstone -	20

This bottom rock, is said, in this locality, to be about 26 feet above the Top-bottom limestone.

The sequence described agreed with that at Poundsford.

The thickness of the top-bottom and bottom was said to vary much, they make the best lime of any.

Rounden Wood.—The beds below the "Blues" are known in Rounden Wood in the following order:—

Feet.		In.	
40	*Main Blue.**	12 or 14	
	Black Blue - - -		A clear compact limestone rather darker than the blues, good lime.
20	*Rounden Greys,* 1st layer -	5 or 6	
5	*Rounden Greys,* 2nd layer -	14	
25	*Rounden Greys,* 3rd layer -	20	A good limestone.
20	*Dunk Shaws* - -	20	Rather dark colour, no grit, good limestone.
14	*The lowest bed known* -	12	No shells.

I had no opportunity of personally verifying the accuracy of this section, as however, the quarryman from whom I obtained the information was perfectly acquainted with the entire series, and as his statement was corroborated in the main particular by others, I feel but little or no doubt of its general accuracy.†

The *lowest bed,* and the Dunk Shaws, occur in Rounden Wood, and the former lies at *one point* within 14 feet of the surface. The Rounden Greys are found in Rounden Wood and at the south edge of Mill Wood, while the Black Blues occur in both these localities and in Darvel Wood.

Poundsford.—The Blue limestones have not been worked in the neighbourhood of Poundsford, their quality being reputed inferior to that of the same beds further east. Little or no information

* Attached to the "Main Blue" in Rounden Wood, and extracted with it in the workings, is a band of oysters known as the "bottom grey." Here it is 3 or 4 inches thick, but it is thinner further to the east. Just above the "8-foot greys" (which lie 8 feet above the "main blue"), there is, in Rounden Wood, a good deal of coniferous wood.—W.T.

† I must, however, observe that as the beds in Rounden Wood, from which this account was principally drawn up, were said to dip (to the N.E.) *at a rather high angle,* the thicknesses are probably uniformly exaggerated. [Sometimes the dip here is 1 in 3, or nearly 20°.—W.T.]

can be gained from the quarrymen here respecting them. The general opinion however is, that the upper layer or "main blue" is absent, and that only the "bastards"* occur.

By an examination of the beds of the small streams transverse to the main valley, and upon the north side of it, I was enabled to discover the outcrop of the Blues in several instances.

The interval between the Greys and the Blues appears to be occupied by shale clay and sand-rock; a few unimportant beds of limestone occur, and a small quantity of clay ironstone. At several horizons the sand-rock contains concretionary layers of Calcareous grit of varying thickness and continuity.

The following is an approximate section of beds exposed in the stream west of Poundsford:—

	Ft.	In.
Shale, including a layer of nodules of clay-ironstone, a few inches thick, a thin bed of blue limestone and some calc grit.	5	0
Shale, including layers of sand-rock which occasionally become converted into calc grit.	10	0
Shale - - - - - - -	5	0
Clay-Ironstone - - - - - -	0	2

I am unable to give the continuation of this section with any attempt at accuracy of detail, but by descending the stream, I found that it was succeeded by alternations of shale, clay, and sand-rock, the first preponderating, for a thickness of from 50 to 60 feet, when the continuity was broken by a fault, and immediately afterwards the blue limestones appeared in place.

In one of the small ravines (locally called gills), parallel to this one, an unctuous blue clay is exposed in the bed of the stream, which has been used with some success as a pigment, and I believe that there are several layers at different horizons in the series which might be similarly applied.

The shales are occasionally bituminous, and it has been proposed to turn this property to account. I am indebted to the courtesy of R. HALLETT, Esq., the owner of Swife's Farm, for the information that he had several tons operated upon, from which was extracted in the first instance tar, and by subsequent processes a variety of products such as pitch, grease, oil, naphtha, and paraffin.

The following is an average vertical section of the Vein Greys in the neighbourhood of Poundsford:—†.

	Ft.	In.
Main Bull, a shelly limestone - - - - -	0	6
Shale, with a thin calcareous band (*Cyrena*) - -		
Sandstone, 4 feet, containing calcareous sandstone of somewhat irregular thickness; fossils abundant, consisting of species of *Cyrena, Melanopsis*, &c., with bones, scales, and teeth of *Hybodus* and Reptiles.	7	0
Shale - - - - - - - -		
Top Crat - - - - - - -	0	5
Strata - - - - - - -	3	0
Irony Crat - - - - - - -	0	6

* I also found them in the stream skirting the Black-brooks Wood, near Glazier's forge.

† Specimens illustrating this and preceding sections are preserved in the Museum of Practical Geology. (See Appendix II.)

	Ft.	In.
Strata	3	6
Paver	0	6
Blue shale Stony bed, 13 or 14 inches, a hard calcareous shale, the bottom resembles a clear limestone, but will not burn.	3	6
Top Vein	1	0
Shale	0	10
Fox or Upper Mealy, principally a hard shale, but there is a thin bed of limestone in the middle, and another at the bottom.	1	0
Clay	1	0
Mealy, shale, clay and a thin bed of limestone	1	3
Clay	1	0
Bottom Vein	0	2
Shale, clay, &c.	2	0
Rotten stone	0	6
Shale, &c.	2	6
Grey Vein	0	3
Shale, &c.	6	0
Top Bottom - 7 or 8 in. Middle - 6 „ Bottom - 10 or 12 „ These three beds with their partings occupy about	4	0

In the east and west stream, south of Poundsford, a little above the junction with the stream running south from Poundsford, the following section of the Greys is seen. The beds are nearly vertical, and the strike is about 15 north of west and south of east:—

	In.
Stony bed	13 or 14
Top vein	12
Fox	12
Mealy	15 inches of shale clay, &c., and a thin layer of stone.
Bottom Vein	1
Rotten stone	3 or 4

The beds above the Greys may be seen in Little Poundsford lane, just south of the stream, where the section, in descending order, is as follows:—

Sand and loam.
Shale, &c., 30 or 35 feet.
Thin bed of limestone (Ragged Bull?)
Shale, &c., 10 or 15 feet.
Limestone (Main Bull?)

The beds dip a little west of south at an angle of 10°.

At Kingsdown Quarry the "Ragged Bull" is 8 or 9 inches thick, and is composed in great part of shells of *Cyrena*, like most of the limestones in this part of the series. The shale in which the limestone occurs is sometimes calcareous and contains an abundance of fossils, mostly *Cyrena*, in a highly friable condition.—C. GOULD.

As very little information can now be obtained concerning these beds, I reproduce a section of a pit at Poundsford, obtained by MR. HUNTER, while the works were still going on. It differs, in some details, from the general succession of beds already given

by Mr. Gould. A section was published by the Rev. A. Young in his Agricultural Survey, but the locality is not given, and he makes the Blues to follow immediately below the Greys, which is certainly incorrect.* Possibly his details for the various beds of each class may be more reliable.

Section at Vertical Shaft to the south of Poundsford Farm.†

	Ft.	In.
1. Soil and alluvium, consisting of mull, sand, clay, and calciferous grit in various proportions - - -	9	0
2. 'Ragged bole' a hard shelly grit, with argillaceous ironstone and sand rock - - - - -	9	0
3. 'True bole.' A compact shelly limestone, occasionally in vein; furnishing excellent lime, though not worked for that purpose; at places, however, earthy and yielding - -	10	0
4. 'Sand rock.' Varies in hardness; lignite and carbonised vegetables are found in this bed, in sufficient quantities to be collected and used for firing, by the workmen. It burns remarkably well, they informed me, as coal -	7	6
5. 'Top Crat.' A mixture of clay, grit, and ironsand, varying in hardness - - - - - - -	1	10
6. 'Irony Crat.' Grit, with shells, remarkably hard - -	1	0
7. 'Pavour.' Well described by quarrymen, as 'like a pincushion,' all full of holes, as if eaten by worms - -	1	0
8 'Stony bed-stone,' sandy shales, of different degrees of hardness. A thin layer of marl between this and the one which follows - - - - - - - -	4	0
9. 'Top vein.' Calciferous grit - - - -	1	0
10. 'Meallies,' (as its name implies) very easily rubbed to pieces —affording, like 'True bole,' very good lime, but not worked - - - - - - -	1	0
11. 'Middle vein.' Very hard grit, containing thin seams of coal - - - - - - -	0	10
12. 'Fox.' A clayey sand, with shells in abundance; affording good lime. Top and bottom coated with shelly shale -	0	11
13. 'Bottom vein,' Gritty limestone; affording, however, very indifferent lime. Between it and following bed, a vein of marl - - - - - - - -	2	9
14. 'Rotten stone,' near bottom vein, marly. Adjoining 'grey vein,' compact sand - - - - -	1	11
15. 'Grey vein.' Varies: in places, crumbling sand; in others hard grit - - - - - - -	0	4
16. 'Blue bed.' Indurated clay, containing very few shells -	1	11
17. 'Top hard bed.' Very like 'Blue bed; 'only in places considerably harder - - - - - -	1	0
18. Red bed. Of a lighter colour than the preceding stratum, inclining to grey, and a great deal harder - - -	1	6
19. 'Irony or hard shelly bed.' Grit with shells. Unless softened by water, the hardest stratum in the whole group - - - - - - - -	0	9
20. 'Bottom bed.' Very like 'Blue bed' - - -	1	6
21. 'Shab.' A species of argillaceous ironstone, with an infinity of small shells, immediately above the first layer of limestone - - - - - - - -	0	11
	59	8

* p. 13 of Ed. 1808.

† Hunter, Mag. Nat. Hist., vol. viii. p. 604; 1835.

The limestone occurs in three layers, shales of various degrees of hardness and consistence intervening as follows, with but very little variation, over the whole quarry :—

	Ft.	In.	Ft.	In.
(1.) First layer of limestone. A compact aggregate of very fine small bivalve shells; the animals of which, judging from their perfect unbroken state, must have lived and died on the spot where they are now collected; many of them not much bigger than a pin's head [*Cypridea*]. Contains very little iron, and affords most excellent lime - - - -	0	11		
(2.) 'Slate bed' 'slate.' Shales more or less earthy; containing occasionally, though very seldom, a long mussel-like shell [?*Unio*]; generally speaking, however, destitute of shells - - - -	0	5		
(3.) The second layer of limestone. Contains a good deal of iron but few shells, and furnishes a very poor lime -	0	5		
(4.) 'Dirt beds.' Earthy shale - - - -	0	11		
(5.) The third layer of limestone. Abounding in shells; and furnishing, like the first layer of limestone, most excellent lime - - - -	0	5		
[?]	3	6		
			3	6
			63	2

Dr. Mantell has published a description of a quarry near Poundsford. This quarry is now overgrown, but there can be little doubt that the beds there worked occur just above the Greys, and in fact lie almost on the same horizon as those already noted at Darvel Beach and Perch Hill. This supposition is confirmed by a MS. section (dated 1826) by Dr. Mantell, now in the library of the Geological Society, in which the Greys are represented below the blue clay and shale, No. 6 of the section.

*Section in a Quarry at Poundsford.**

	Ft.	In.
1. Loam. - - - - - - - -	8	0
2. Bed of laminated shale, clay, &c., containing thin septaria of ironstone, with bivalves, and a layer of *very hard, dark blue limestone* [Ragged Bull], 2½ inches thick; similar to the most compact masses of Archer's Wood.	2	5
3. Bluish grey loam, or soapy marl - - - -	3	9
4. Friable sandstone, with traces of carbonized vegetables -	5	6
5. *Compact calciferous grit* [Rock] containing casts of *Cyclas* [*Cyrena*] *parva* and *media*; lignite, and traces of carbonized vegetables; and bones and teeth of reptiles.	1	10

6. Blue clay, and shale—depth unknown.

The strata dip to the N.N.E., at an angle of about 5°.

Sub-Wealden Boring.—This bore-hole is put down in Councillor's Wood, just south-east of the stream which divides that wood from Limekiln Wood. On the Ordnance Map the whole wood is marked *Limekiln Wood*, and as such it has been described in this Memoir.

The spot, which was selected by Mr. H. Willett and Mr. Dawkins, is admirably adapted for the work, it is low down in the series, just below the "main blue," and the beds are there lying almost horizontally. There are other spots within the Purbeck area at which the boring might have begun in lower

* Mantell, South-east of England, p. 222.

beds, and one of these were at first chosen but had to be abandoned; but probably at no other place could such low beds be reached where the rocks are so little disturbed.

The Greys and Blues have both been worked in the woods around. The Blues only over a comparatively small area around the boring, for the beds dip from near here both up and down the stream, so that in going in either direction higher beds come on. The beds in the stream close to the boring are the "Bastard Blues." They consist of rather impure earthy limestone, separated by shales, strikingly resembling the lowest lias in lithological characters. In ascending the stream we find that the beds roll about a good deal, but have a general dip to the south and west, which quickly brings in the higher beds. About a quarter of a mile above the boring there is a good section of the "Bottom White" and the "8-foot Greys," with about five feet of shale between. It is at this place that the shale occurs which slightly resembles the leathery shale of the Greys. Still higher up the stream there are sections showing the shales with sandstone between the Greys and Blues, but the beds here are generally much disturbed. Still higher up many old workings of the Greys occur, and here, too, there is a quarry where the Tilgate stone or "rock" immediately above the Greys is worked.

In descending the stream from the boring the beds are found to be much disturbed; they are the shales and sandstones above the Blues. At one place, about a quarter of a mile below the boring, there is an interesting section of shale.* There is a rather hard calcareous bed, composed almost entirely of *Cyrena*, but also containing *Mytilus* and *Ostrea*; there may be two species of Ostrea, one a rather large form. Above this is soft dark shale, with *Modiola, Corbula*, &c.

The Sub-Wealden Boring, commencing just below the "main blue"—for the ground around has been all worked over—must of course pass through the lower beds of Rounden Wood, or the representatives of them; but the two series cannot be correlated. It may be that the thickness allowed in the section on p. 32, and that given in the text on p. 37, may be too great, and that the top beds of the bore-hole may represent the Rounden Greys. Still, even if this be the case, the succession does not appear to be the same in the two districts. The "Dunk Shaws" of Rounden Wood are crowded with *Cypridea Valdensis*; and although the beds pierced in the boring have been carefully examined, no such stratum has been there observed.

The gypsum found in the bore-hole is an important addition to the Purbeck series of Sussex. Nothing of the kind has been observed in the higher beds†; but it occurs in some quantity in the lower part of the Purbecks of Dorsetshire. The two beds of gypsum found in the bore-hole consist of perfectly white alabaster. The gypseous shales are dark in colour, but contain so much

* This section, which was first noticed by Mr. Henry Willett, is not very easy to find; it is on the right bank of the stream.

† The selenite noticed in the shale above the blues (p. 31), is the result of weathering, as is often the case with clay and shales.

gypsum that they take a light colour, sometimes almost white, when ground into powder.

The thick masses of gypsum seem to be evenly bedded, but that found in the shales is nodular and irregular in structure. Judging from what is known of the mode of occurrence of gypsum in other districts, it is unlikely that even the thick beds will be constant; but it is very probable that, at or near this horizon, gypsum will occur over a considerable area in the Sussex Purbecks,* and it probably occurs at no great depth below the surface at the bottom of the "Rough Field" in Rounden Wood.

Section of Strata passed through in the Sub-Wealden Boring (Sept. 1874).

		Thickness.		Depth from Surface.	
		Ft.	In.	Ft.	In.
Purbeck Beds, 180 feet.	Shales	16	6		
	Blue limestone (Spring tapped here)	2	6	19	0
	Shale	5	0	24	0
	Blue limestone	2	0	26	0
	Shale	4	0	30	0
	Limestone	1	6	31	6
	Shale	4	0	35	6
	Limestone	3	0	38	6
	Shale (Spring tapped here)†	4	0	42	6
	Limestone	4	0	46	6
	Hard blue shale	15	6	62	0
	Hard grey shale	3	0	65	0
	Hard shale	14	6	79	6
	Shales with crystals of carbonate of lime	9	0	88	6
	Grey shale	13	0	101	6
	Greenish shales with gypseous veins	20	0	121	6
	Impure gypsum	8	6	130	0
	Pure white gypsum	4	0	134	0
	Impure gypsum	5	6	139	6
	Pure white gypsum	3	0	142	6
	Gypsum, more or less pure, hard and dark	14	6	157	0
	Black shale (very sulphurous)	3	6	160	6
	Gypsum in nodules and veins	12	0	172	6
	Gypseous marl	6	6	179	0
	Sandy marl (water level lowered here)	0	6	179	6
	Black sulphureous shale	0	6	180	0
? Portland Beds, 110 feet.	Greenish sand with nodules of black chert	21	0	201	0
	Sandy shale	30	0	231	0
	Calcareous matter with chert nodules	8	0	239	0
		2	0	241	0
	Hard black sandy shale, very sulphureous	12	0	253	0
	Blacker and softer shale	7	0	260	0
	Harder shale with much chert	12	0	272	0
	Black shale, very sulphureous	14	0	286	0
	Shale, paler in colour, with veins of gypsum	4	0	290	0
Kimeridge Clay, 666 feet.	Shale, darker and more sandy	2	0	292	0
	Shale	2	0	294	0
	Dark clay	18	0	312	0
	Clay, generally rather sandy, some of it calcareous towards the lower part	288	0	600	0
	Hard light-coloured bed, very rich in Petroleum	2	0	602	0
	Clay, with bands of Cement stone	232	0	834	0
	Cement stone	50	0	884	0
	Clay	2	6	886	6
	Cement stone	2	6	889	0
	Clay	67	0	956	0
Oxford Clay.	Dark clay, with Cement stone	55	0	1,011	0
	Sandy bed	2	0	1,013	0
	Dark clay	4	0	1,017	0

* It has lately been found by MR. BOSWORTH in a boring at Archer Wood.
† The water stands permanently at 42 feet from the surface, inside the lining-tubes.

Owing to the absence of the Coral Rag there is some difficulty in fixing upon a definite boundary between the Kimeridge and Oxford Clays. A characteristic Kimeridge Clay fossil (*Gryphæa virgula*) occurred at 950 feet, and an Oxford Clay fossil (*Ammonites Sedgwicki*) at 967 feet. At 956 feet there is a rather sandy parting containing numerous specimens of a smooth *Astarte*. I would suggest that this may conveniently be taken as the boundary line; but it must be remembered that, so far as we can judge, there is no natural line between the two clays.

To the depth of 312 feet a 9-inch hole was put down by MR. J. A. BOSWORTH. At the end of 1873 the work was transferred to the Diamond Rock Boring Company, by whom the boring has been carried to its present depth; from 312 to 328 feet, a 4-inch hole was made, giving a 3-inch core; below 328 feet it is a 3-inch hole, giving a 2-inch core.

As the boring is incomplete it may be sufficient in this place to rest content with the foregoing statements, merely adding the following lists of fossils which have been collected from the cores by MR. H. WILLETT, MR. PEYTON, and myself. MR. ETHERIDGE has given me his valuable aid in naming them, and I have also to thank MR. DAVIDSON and DR. LYCETT for kind assistance.

LIST of FOSSILS from the SUB-WEALDEN BORING (from 300 feet to 1,013 feet).

Those marked * occur only in the Oxford Clay.
" " + " both in the Kimeridge and Oxford Clays.
All others have been noticed in the Kimeridge Clay only.

Serpula.

Cidaris Boloniensis, Wright.

**Pollicipes concinnus ?* Sow.

Discina Humphriesiana, Sow.
D. latissima, Sow.
+ *Lingula ovalis*, Sow.

+ *Arca.*
Astarte Hartwellensis, Sow.
A. ovata, W. Smith.
A. Mysis, D'Orb.
A., new species.
+ *Avicula.*
+ *Cardium striatulum*, Sow.
+ *C. striatulum*, var. *lepidum* Sauv. et Rigaux.
+ *Corbula.*
**Gervillia.*
Gryphæa (*Exogyra*) *nana*, Sow.
G. virgula, Defr.
Hinnites ?
Leda.
L., allied to *L. Dammariensis*, Bu
Lima.
Lucina.
**Macrodon.*
Modiola, new species.
Myacites.
Nucula.
Opis.
Ostrea deltoidea, Sow.
O. Thurmanni (var. of), Etallon.
+ *O. ?* sp.
Pecten arcuatus, Sow.
P., a form with coarse ribs.
Pholas compressa ? Sow.
Pholadomya.
+ *Tellina.*
+ *Thracia depressa*, Sow.
Trigonia Juddiana, Lyc.
T. Pellati, Mun. Ch.
T. ? new species.

+ *Alaria.*
+ *Cerithium.*
Pleurotomaria reticulata, Sow.
**Tornatella.*
Turbo.

Belemnite.
+ *Ammonites biplex*, Sow.
**A. Jason*, Rein.
**A. Lamberti*, Sow.
**A. Sedgwicki*, Pratt. (? var. of *A. Jason*).

+ *Hybodus.*
+ Fish remains.
+ Coprolites.

CHAPTER IV.—HASTINGS BEDS.

1. Hastings and Battle District.

This district has the anticlinals of Brightling and Fairlight nearly along its central line, which correspond very nearly to the line of highest ground. Along this line the Ashdown Sand occupies the surface, and, dipping more rapidly than the slope of the ground, passes under higher beds on the north and south.

It is bounded on the north, from near Rye westwards, by the Rother; taking that branch of the river which flows on the south of Mayfield from its source at Castle Hill Rotherfield. Its western boundary is formed by the eastern branch of the Ouse, which, also rising at Castle Hill, flows past Hugget's Furnace and Buxted to the main river at Isfield.

The greatest exposure of the Ashdown Sand is near Heathfield. The area occupied by this division is narrowed near Mountfield, but expands again on the east of Battle. Here, however, there are many outliers and faulted patches of Wadhurst Clay.

The Tunbridge Wells Sand does not occupy much ground in this district. The main exposure is where it crops out from beneath the Weald Clay on the south-west; over Hadlow Down on the north-west; and around Peasemarsh on the north-east. In the district south and south-west of Battle the area taken up by this division is fairly large, but it occurs only as outliers.

Fairlight Clays.—These are brought up to view both on the east and west of Hastings. In the latter place by faults; in the former by an anticlinal, which runs in the same general direction as that which brings the Purbecks to the surface in the district already described, but which is probably not the same line.

The great mass of Ashdown Sand forming the East Cliff dips very gradually to the west, and from beneath, at about the last house on the beach, some clayey beds rise which are the top of the Fairlight Clays. From this point there is a general rise of the beds eastwards until between Fir Hill and Straw's Castle,* the whole cliff is occupied by the Fairlight Clays; from thence eastwards the beds dip east and finally disappear against a fault (Fig. 2.)

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* So marked on the map, but the name is now scarcely known there; the place is called the Haddocks.

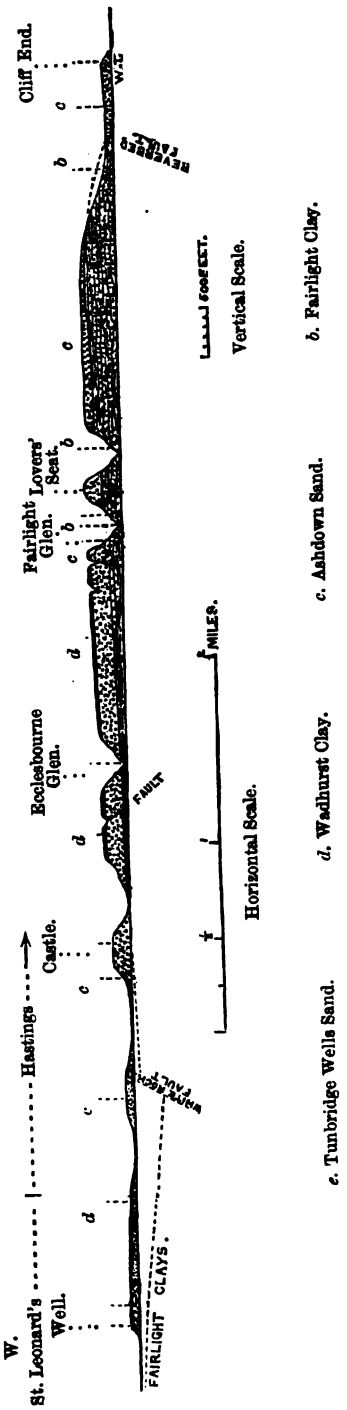

Fig. 2. Cliff Section from St. Leonard's to Cliff End.

The beds first seen east of Hastings are alternations of clay and sandstone, the former predominating, as is the case throughout the whole series. The junction is not very definite, although as a whole the Fairlight Clays are well distinguished from the Ashdown Sand by the quantity of clay which they contain.

The small fault west of Ecclesbourne Glen throws to the north-east, about 30 feet, and brings the Ashdown Sand again down to the beach. The following is the order of the beds as they rise east of the fault:—

		Ft.	In.
Ashdown Sand.	Sandstone - - - - -		
	Clay parting - - - - -	1	0
	Sandstone - - - - -	12	0
	Clay parting - - - - 6 in. to	1	0
	Hard sandstone - - - - -	6	0
Fairlight Clays.	Slate-coloured clay - - - -	6	0
	Hard sandstone - - - - -	2	6
	Grey and slate-coloured clay, sandy below -	4	0
	Hard sandstone - - - - -	2	0
	Grey and slate-coloured clay, sandy below, with a hard pinkish oolitic-looking bed, 3 to 6 inches thick, near the bottom.	7	0
	Irregular interbeddings of sand, sandstone, sandy clay, lignite, and ferruginous beds, passing sometimes into clay-ironstone, one conspicuous bed of which thickens out to 18 inches.	20 to 25	0
	Strata (concealed by shingle) - - about	5	0
	Sandstone - - - - -	4	0
	Compact slate-coloured sandy clay - -		

False bedding on a large scale is seen in the cliff a little east of Ecclesbourne Valley (Fig. 3). It seems almost like a slight unconformity between the Ashdown Sand and Fairlight Clays, as the lowest of the horizontal sandstone beds is at about the base of the Ashdown Sand.* False-bedding is also very apparent in the cliff just west of the stream that comes down from Warren House, east of Fairlight Glen.

Fig. 3. Sketch of False-bedding in Cliff, East of Ecclesbourne.

c. Ashdown Sand. *b.* Fairlight Clays.

The dark shading represents clay and shale; the light shading sand and sandstone. The harder beds are shown by vertical lines.
Length about 150 yards; height about 50 feet.

The first distinct traces of mottled clay are seen at the base of the cliff just west of a small gully between Ecclesbourne and

* Compare this sketch with fig. 13, p. 83.

Fairlight Glens. The mottled clays increase in quantity as lower beds come into view, until to the east of Fairlight they give the prevailing colour to the beds of these very beautiful cliffs.

The following is a detailed section of these cliffs, measured by MESSRS. DREW and GOULD:—

Section of the Cliffs, measured at different points, near the H. of Signal Ho.

		Ft.	In.
Ashdown Sand.	Clayey sand-rock	30	0
	Sand-rock	30	0
	(not seen, probably sand-rock)	10	0
Fairlight Clays, 286 ft. 9 in.	(not seen, probably clay)	10	0
	Unctuous clay, drab and buff, mottled with red	5	0
	White sandstone	1	6
	Clay, blueish grey	3	0
	Hard sandstone	1	6
	Clay, blueish drab	3	0
	Very hard sandstone	9	0
	Clay, with ferruginous veins (and *Chara* ?)	8	0
	Sandstone	1	0
	Red and blue clay	3	0
	Sand-rock (? *Chara*)	8	0
	Shale, with lignite at the top occasionally, passing down within a few feet into greyish-blue clay.	20	0
	Hard rock, composed of { Sandstone	1	0
	Hard rock, composed of { Limestone	0	9
	Red, yellow, and grey clay	15	0
	Sand-rock, hardened irregularly by ferruginous matter	12	0
	Shale, with ferruginous matter	12	0
	Red and grey clay	25	0
	Sandstone, slightly ferruginous	2	0
	Clay	8	0
	Sandstone	1	0
	Clay	12	0
	Sandstone	4	0
	Clay, white, yellow, and red	10	0
	Ferruginous sandstone, with fish, vegetable remains, and lignite.	6	0
	Hard shale	4	0
	Sandstone, with a little shale and lignite	3	0
	Clay, of a general purplish grey tint, with some white sand, and a few courses of sandstone and pisolitic iron ore.	64	0
	Sandstone, tesselated	4	0
	Clay, whitish blue, and mottled	20	0
	Sand-rock	2	0
	Clay	8	0

The crest of the anticlinal is about S.S.E. of the *H.* of *Signal Ho.*, from here the beds dip gently along the cliff in both directions; they are thrown down by the reversed fault near Straws Castle.

The lowest beds of the foregoing section, from the tesselated sandstone downwards, are tolerably constant, all above are more or less variable. The tesselated sandstone has some resemblance

to the bed described by MR. BECKLES* at Ecclesbourne, and he apparently considers it to be the same (see woodcut to the memoir referred to). A bed also resembling it occurs just below the shingle opposite Fairlight Glen, and again opposite the mouth of the stream from Warren House. Between these points, and only a little east of Fairlight Glen, is an irregular looking bed, like that seen at the base of the cliff at Ecclesbourne. The sandstone beds referred to occur at very different depths below the base of the Ashdown Sand (that at Ecclesbourne 50 feet, that at Fairlight 250 feet); and if, as MR. BECKLES supposes, they are really the same bed, then the strata above thicken out in a short distance to the extent just named. But the beds cannot be continuously traced, and they are therefore here considered to lie on different horizons. It should also be mentioned that in MR. BECKLES' section the beds in question are shown coming up below high water mark *east* of the reversed fault, where the whole cliff is formed of Ashdown Sand. This would require nearly the whole of the known Fairlight Clays to have thinned away.

The Fairlight Clays occur close to the surface a little north of the Land Gate at Rye; and they also no doubt underlie the alluvium of Romney Marsh in many places. At Bachelor's Brewery, Rye, they have been bored into to a depth of 330 feet, as shown in the following section, communicated to MR. DREW by MR. J. ELLIOTT, the engineer of Romney Marsh †:—

		Ft.
Alluvium	Clay - - - - - - -	3 or 4
	Peat, with logs of wood in it - -	6 or 8
Fairlight Clays.	White and red mottled clay, with several layers of sandstone, one (at a depth of about 150 feet) 23 feet in thickness, and a few thin layers of hard rock.	330

The inland country occupied by the Fairlight Clays, between Guestling, Pett, and Fairlight, has generally a wet and somewhat stiff soil. The line of junction with the Ashdown Sand is doubtful; but while the area coloured on the map as Ashdown Sand is for the most part light and sandy, that where the Fairlight Clays occur is mostly clayey with a good deal of red clay in some places. There are no good sections over this district; but the beds may be seen in the railway cuttings by Ore Tunnel, where they consist of white sandstones and clay with ironstone, some of the clay being red and mottled. Mottled clay is also seen faulted against sand and sandstone (probably Ashdown Sand) in the brickyard above Ore Tunnel, just east of the shaft.

The Fairlight Clays have been reached in a deep bore-hole at the Hastings Waterworks. This well and boring commences in the Wadhurst Clay, passes through the whole thickness of the Ashdown Sand, and reaches down 333 feet into the Fairlight Clays.

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* *Quart. Journ. Geol. Soc.* vol. xii. p. 288.

† *Memoirs Geol. Survey*, Sheet 4, p. 5, 1864. The beds here described as Fairlight Clays were then known as Ashburnham Beds.

Section of Strata at Hastings Waterworks. (From a MS. section in the Borough Surveyor's Office, Hastings.)*

		Ft.	In.
	Vegetable soil	1	0
Wadhurst Clay 16 ft. 9 in.	Light-coloured clay	0	9
	Dark blue clay	2	0
	Stiff " "	4	6
	Clay and Marl, impregnated with iron	1	2
	Clay and ironstone	3	4
	Clay, marl, shale, and ironstone	5	0
Ashdown Sand, 145 ft. 9 in.	Beds of hard stone	6	2
	Sandstone	4	0
	" with beds of hard stone	8	3
	Hard stone	4	0
	Sandstone	8	0
	Hard stone	1	0
	Sandstone with large open vents	4	0
	Marl	6	0
	Sandstone with open vents	9	0
	Marl and stiff blue clay [with *Endogenites erosa*]	22	0
	Blue clay with thin beds of hard stone	5	0
	Hard sandstone	13	3
	Clay	1	0
	Sandstone with clay	4	0
	Stiff blue clay, with thin beds of sandstone	7	7
	White sandstone	28	6
	Blue sandy clay	1	0
	White sandstone	13	0
Fairlight Clays, 333 ft.	Stiff marly clay [slightly mottled]	5	0
	Dark sandstone	5	0
	Stiff blue clay	14	0
	Clay with marl [slightly mottled]	7	0
	Clay with veins of lignite and vegetable mould	10	0
	Sandy marl	13	0
	Sandstone	14	0
	Marl	12	6
	Sandstone	3	6
	Dark stiff sandy marl	10	0
	Dark stiff clay	8	6
	Hard blue stone	11	6
	White sand	35	0
	Marl	3	0
	Stiff blue clay	14	0
	Coloured clay	16	6
	Light red sandstone	14	6
	Dark stiff blue clay	25	0
	Coloured clay with yellow streaks	10	0
	Sandy marl with veins of stone	14	0
	Coloured clay	2	0
	Clay [red in the upper part]	18	0
	Pipe clay	3	0
	Light blue clay	5	0
	Light-coloured clay	6	0
	Dark red clay	2	0
	Light-coloured clay	1	0
	Very dark red clay	3	0
	Light-coloured clay	6	0
	Light-coloured sandy clay	18	0
	White sandstone	1	9
	Light-coloured clay	1	3
	Dark red-coloured clay	5	0
	Dark green mottled sandy clay	15	0
	Sandy clay		
		496	6

* In this office is preserved a complete set of specimens from the well.

A borehole at the Pelham Baths, Hastings, was put down in 1829. It commenced nearly at the bottom of the Ashdown Sand. The beds passed through are mentioned by BAKEWELL * as being chiefly clay; water was obtained at 260 feet, and rose nearly tothe surface.

The towns of Hastings and St. Leonard's stand on higher beds in the series, but at the extreme west end of the latter place, at Bopeep, some mottled clays occur which are probably Fairlight Clays.

The first cliff west of St. Leonard's, at Bulverhithe, is composed of Ashdown Sand, but to the west of that the Fairlight Clays rise and occupy most of the cliff on which Tower No. 44 is built (Galley Hill). They consist of clay, much of which is brightly mottled, and some sandstone. The cliff is traversed by several small faults, and one of greater magnitude brings the Ashdown Sand down against the Fairlight Clays which are seen no further west. There is probably an east and west boundary fault north of the Tower, the position of which is quite uncertain. It has been drawn north of the railway on account of some mottled clay seen in the cutting; but the beds here exposed are mainly sandstone and may be all Ashdown Sand, as mottled clay, though eminently characteristic of the Fairlight Clays is by no means confined to them. The cliff section is shown in the following sketch by MR. AVELINE † (see next page).

ASHDOWN SAND.—This division occupies some of the highest ground of the country, having been raised to this position by the great anticlinal before mentioned. It also occurs at the lowest levels, being frequently exposed by denudation along the valleys; its thickness, on the East of Hastings, is about 150 feet.

Coast Section.—On the coast, about two miles west of Bexhill, the Ashdown Sand rises from beneath the Wadhurst Clay, and forms a low range of cliffs. The beds are very inconstant in character, consisting of thinly bedded sandstone and sandy clay with some ferruginous beds and lignite. About a quarter of a mile west of Tower 47 there is a bed of lignite, which is in one place a foot thick, but it soon dies away. A bed of lignite, probably the same, is exposed on the west side of Tower 46 where it is two feet thick. The Ashdown Sand disappears inland under the great mass of Wadhurst Clay, and on the east it is brought against the Fairlight Clays by a fault, as already described. Sandstone and sandy clay occur over the mottled clays at Galley Hill (Tower No. 44); from thence they dip slightly eastwards and the next cliff, on which Tower No. 43 is built, consists entirely of soft sandstone with some ironstone and sandy clay.‡ White sand-

* Introduction to Geology, 5th ed. 1838, p. 632.

† A section of the coast here is given by PROF. T. R. JONES, "Fossil Estheria" (Palæontographical Society), p. 108.

‡ The footprints described by MR. BECKLES along this coast, probably chiefly occur in the Ashdown Sand, but some appear to be in the Wadhurst Clay. *Quart., Journ. Geol. Soc.*, vol. x. p. 457. See also MR. A. TYLOR's paper, *Ibid.*, vol. xviii. p. 247.

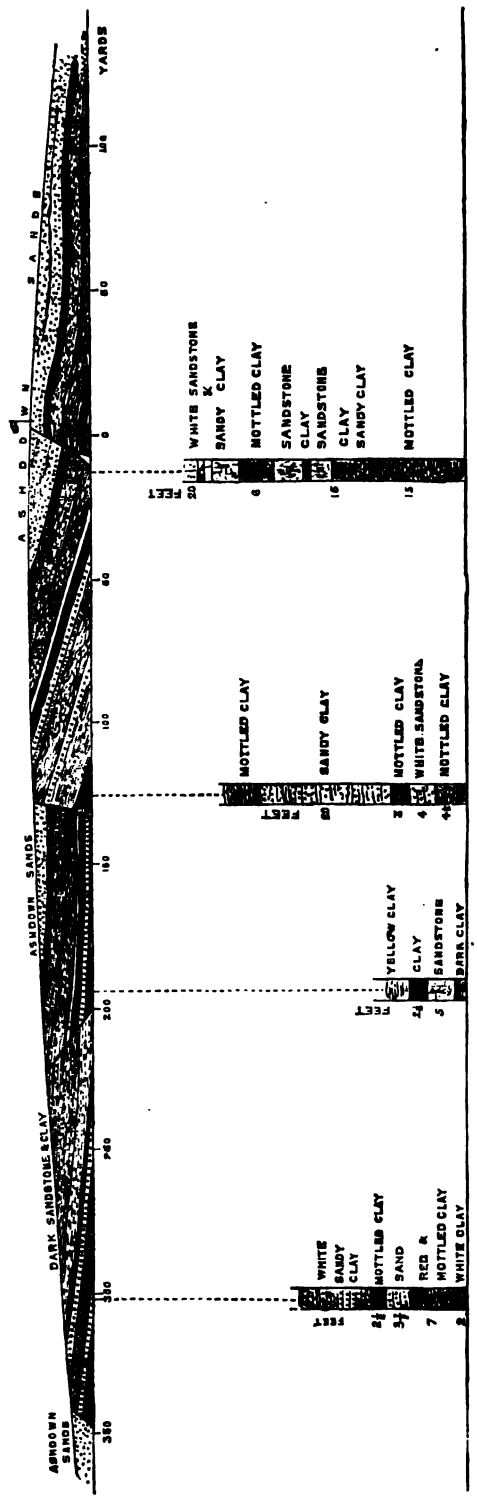


Fig. 4. Section of the Cliffs west of Bulverhithe.

stone is seen in the railway cutting at Bexhill Station; these are the top beds, which also occur fringing the alluvium above Bulverhithe, and are exposed in the valleys of Crowhurst Park.

The cliffs at the western part of St. Leonard's are formed of Ashdown Sand, capped by clayey beds of the Wadhurst Clay. There is a conglomerate just below the junction, which sometimes contains fossils. At Bopeep Station some mottled clay occurs which is assumed to belong to the Fairlight Clays. At a well sunk to supply St. Leonard's with water, 111 feet of strata were passed through, below which a bore-hole was put down 173 feet further. The section of this well, which was kindly procured for me by the late MR. J. C. SAVERY, is rather difficult to understand. The beds passed through in the bore-hole are probably Fairlight Clays, but the upper 111 feet may belong to the Ashdown Sand. The "Limestone rock" is perhaps calcareous sandstone (Tilgate stone).

Section of the Well and Bore-hole at the St. Leonard's Waterworks, 1866.

	Ft.	In.
Soil, &c. (surface)	3	0
White sand	21	0
Brown „	5	0
Coarser brown sand	4	0
Slaty marl	1	0
Ferruginous sand rock	4	0
Marl (with shells)	1	0
Strong blue clay	5	0
Hard yellow sandstone rock	2	0
Grey sandy marl	1	0
Variegated „	1	0
Yellow sand rock	2	0
Grey slaty marl	1	0
Grey soft stone	3	0
Grey marl	1	6
White „	1	6
Grey „	1	0
Yellow and blue rock	0	8
Soft grey marl	3	0
Marl	2	6
Hard limestone rock	4	0
„ „ , blue	3	0
White clay	10	0
Grey „	1	0
Yellow and blue veined rock	1	0
Darker „ „	1	0
Brown rock	0	8
Grey hardish rock	3	0
Bluish rock	6	0
Bluish clay	2	0
Rock	0	4
Limestone rock	5	0
„ „	10	0
Depth of well	111	2

Boring :—

Strong blue clay	27	0
Clay and sand	7	0
Strong blue clay	8	0

	Ft.	In.
Strong clay mixed with lignite - - -	9	0
Hard rock - - - - - -	9	0
Strong clay (with a little sand and rock) - -	12	0
Mottled clay - - - - - -	17	0
Sand - - - - - - -	7	6
Rock sand - - - - - -	8	6
Mottled clay - - - - - -	13	0
Clay - - - - - - -	3	0
Hard compact clay of various tints, with thin layers of rock.	51	10
Total depth - -	284	0

The old town of Hastings is built entirely on Ashdown Sand, whilst St. Leonard's is mainly built on Tunbridge Wells Sand, the two series being brought together by the "White Rock Fault." The Ashdown Sand forms the fine cliffs on which the Castle is built; here the beds consist of compact white rock-sand, resting below on beds somewhat more clayey in character, which may be seen in excavations on the west side of the Castle Cliffs, near the new Post Office.

The top beds are generally massive, and form a range of bare rocks around the Hastings and Ecclesbourne valleys. This is their general character, not here alone, but throughout the entire district; whilst the lower beds are much more variable in character. The East Cliff is composed almost entirely of sandstone like the Castle Cliff, but in going along the shore eastwards the beds rapidly change in character, becoming less massive and containing intercalated beds of clay. This change is plainly indicated by the different forms assumed by the cliffs; those at Hastings weathering into vertical faces, whilst those nearer Fairlight present a succession of steps.

In the Cliff behind the White Rock Brewery there is a clear section of the Ashdown Sand, showing a bed of shale 10 feet thick with ironstone and *Endogenites erosa.* In the East Cliff, about 30 feet below the base of the Wadhurst Clay, *Endogenites* occurs, and it was also found in the well at the Hastings Waterworks at a slightly greater depth (see section on p. 50).

The top of the East Cliff from Hastings to Fairlight is composed of Wadhurst Clay, and the lower part, as already described, of Fairlight Clays.

Just east of the town, on the top of the cliff, the junction beds are as follows:—

	Ft.	Ft.	In.
Shale and Clay, with thin bands of clay-ironstone -	10 to	15	0
Sandstone thinly bedded; some shaly - - -		2	6
Rock-bed, coarse at the top. (Top bed of Ashdown Sand.)			

Further east, at the small gully west of Ecclesbourne, is the following section:—

		Ft.	In.
Wadhurst Clay.	Sandstone forming the top of the cliff (a bed in the Wadhurst Clay). - - - -		
	Dark clay and shale - - -	about 10	0
	Sandy shale - - - - -	6	0
	Tilgate stone and sandstone - - -	4	0
	Clay, shale, and ironstone - - -	about 10	0
Ashdown Sand.	Rock bed.		

The Ashdown Sand is here about 150 feet thick, and is succeeded below by the Fairlight Clays, a section of which is given in detail on p. 47.

At the head of a small ravine between Ecclesbourne and Fairlight Glens the beds are again well seen, as follows:—

		Ft.	In.
Wadhurst Clay.	Clay and blue shale	10	0
	Shelly clay-ironstone	0	6
	Sandstone and shale; sometimes calcareous and passing into Tilgate stone.	4	0
	Calcareous sandstone (Tilgate stone)	4	0
	Clay and shale with thin layers of sandstone	14	0
	Sand and sandstone	2	6
	Lignite	1	0
Ashdown Sand, 150 feet.	Massive bed of sand-rock	12	0
	Sandstone with partings of shale and ironstone, and thin beds of lignite, 1 inch thick, at top and bottom.	17	0
	Shale and clay with ironstone	24	0
	Sandstone, with partings of shale and ironstone	97	0

Then follow beds of clay with thin sandstones and loams for 90 or 100 feet, all apparently belonging to the Fairlight Clays, although the junction is not very clearly marked; mottled clay occurs at about 75 feet from the top.

Further east the cliff intersects a fault with a throw of about 50 feet down to the south and west; here the cliff recedes inland, behind the undercliff, towards Fairlight Glen, and from hence eastwards the cliffs are wholly composed of Fairlight Clays until the reversed fault at Straw's Castle is passed, where the sands are again brought down to the level of the beach.

North-east of Hastings.—Inland, the Ashdown Sand spreads over a considerable area around Pett, Guestling, Westfield, &c.; and it forms the crest of the ridge of Fairlight and Ore. The highest points attained in this part of the country are on these sands; Fairlight Church being 518 feet above mean sea level, and the Mill 583 feet.

The general character of the beds inland seems much the same as in the cliffs east of Hastings; that is, sandstone with thin beds of clay and loam with clay-ironstone. A conglomerate bed occurs in some places at the top of the sands. A very good section is seen along the road east of Fairlight Church, where the beds are as follows:—

	Ft.	In.
Thin Sandstone and Sand	10	0
Sandstone	3	6
Clay, with three or four inches of clay-ironstone at the top 8 inches to	2	0
Sandstone	1	0
Clay parting	0	1
Sandstone, coarse at the top with pebbles, rather clayey below	2	0
Hard Sandstone	2	0
Clayey Sand	2	0
	22	7

These beds are in the lower part of the sands, and somewhat resemble those in the lower part of the Castle Cliff.

"In a large quarry north of Ore a very good junction of Ashdown Sand and Wadhurst Clay is to be seen:—

d. Thin bedded sandstone.
c. Dark and light-coloured clays.
b. Thin sandy clay shales.
a. Thick bed of white sandstone, with perpendicular joints.

"The sandstone is composed of fine grains of white quartz, not very hard. The stone is used for building, being procured in large blocks measuring 6 × 4 × 1½ feet. There are casts of fossils in these beds.

"North of this quarry there is a well between 80 and 90 feet deep, in which was found sandstone 40 feet thick, then dark shaly clay with carbonaceous matter. Below this there was some very tough brown sandstone.

"From this well the beds dip northwards at about the same angle as the slope of the hill, carrying the Wadhurst Clay into the valley, but before reaching the brook the beds are much disturbed, being nearly vertical." *

A bed of shale and clay is worked for bricks south of Ore parsonage and along the hill-side eastwards; this is in the Ashdown Sand. Shale and clay, possibly the same, are also seen in the road ⅜ths of a mile due west of Merry Dames. It is 20 or 30 feet thick, and is underlain by a rock-bed dipping sharply down the hill to the north. Between Beam's Farm and Westfield sandy clay and shale occur, also at Westfield Church. In the road going east from Icklesham, towards Winchelsea, there is loam and clay in the sands; and clay with some ironstone occurs to the S.S.E. of Conster Farm, about half way between Brede and Beckley.

The top beds immediately under the Wadhurst Clay are more constant in character and frequently, as already mentioned, stand out in natural rocks; not always in so picturesque a form as at Hastings and Ecclesbourne, but they often protrude through the soil and are well exposed in roads and paths. The upper part is often coarse and sometimes becomes a conglomerate. The same order is repeated at different horizons in the Wealden rocks, for we very frequently find rock-beds underlying clay, with the upper part of the rock coarse or containing pebbles. This occurs also at times even with the subordinate beds of each division, an instance of which may be seen in the road leading south-west from Winchelsea, where at the bend of the road the sand rock contains a bed of loam and clay two to three feet thick, enclosing a layer of concretionary clay-ironstone, not constant, but varying in thickness from 0 to 12 inches, and when not present being replaced by stiff clay. Under this the rock-bed is coarse at the top, and contains some small pebbles.

Beds of Tilgate stone (calcareous sandstone) occur just above the top of the Ashdown Sand in the East Cliff, but occasionally

* From Mr. Aveline's notes.

they are found in the sands; as, for instance, behind the White Rock Brewery, in sands above the "Endogenites shale." At the *s.* of *Nilstone*, near Udymer, masses of Tilgate stone occur in the sand.

The Ashdown Sand at Rye is about 160 feet thick, nearly the same as at Hastings. It occupies most of the country by Udymer, Brede, and Sedlescomb, the higher ground of which is capped by outliers of Wadhurst Clay. Very generally over this area the top beds of the sands are rocky and mostly coarse grained. This mass of sands joins the sands of Peasemarsh and Beckley, from beneath which on the north the Wadhurst Clay crops out; they are, therefore, Tunbridge Wells Sand brought against the Ashdown Sand by a fault, with a downthrow to the north.

The following is an extract from MR. DREW'S Memoir on Sheet 4:—

"These beds, which attain a thickness of about 160 feet, consist almost entirely of sand; the topmost beds are generally a hard sand or 'rock-sand.'* In some places, however, in the upper part of the formation one finds lenticular masses of a fine hard grey calcareous grit, which forms a serviceable roadstone.

"The following are the chief sections of the Ashdown Sand:—

"The cliff that bounds, on the south and east, the hill on which Rye is built consists of sand containing masses of calcareous grit.

"A similar section is presented by the cliff at Scots Float Sluice.

"A sand-pit a little N.W. of Playden Church shows the top of the Ashdown Sand to be a moderately coarse white rock-sand.

"The road leading eastward down Boon's Hill gives a section of white and buff rock-sand coming from underneath the Wadhurst Clay, with masses of calcareous grit a little below the junction.

"By Thorndale Farm a pit shows the same beds with an eight-inch layer of grit exactly at the junction."

North and North-west of Hastings.—In the cutting at the south end of Mountfield Tunnel is the following section:—

	Ft.
Clayey sand-rock - - - - - - -	15
Buff sand-rock, with occasional tabular masses of ironstone at its base, from four to six inches thick.	5
Sand-rock, less compact - - - - - - -	7
Clayey sand, with occasional tabular masses of ironstone about seven feet down.	12

The beds here are almost flat.

An excellent junction section is seen at Perryman's, 1½ mile S. of Burwash:—

		Ft.	In.
Wadhurst Clay.	Clay - - - - - - -	3	0
	"Shelly Bed" - - - - - -	0	2½
	Shale - - - - - - -	3	0

* "I have used the word 'Rock-sand' as a convenient term to denote a hard massively bedded sand, sufficiently compact to form natural rocks, but not close enough to constitute a sandstone fit for building purposes."

		Ft.	In.
Ashdown Sand.	Shaly loam	1	0
	Soft sandstone	0	4
	Conglomerate	2 in. to 0	6
	Rock-sand	1	6

The conglomerate varies in character, being in some places scattered through the sandstone in single rows of small pebbles.

The beds here dip sharply east and thus rapidly descend the hill to the stream on the north; here the beds flatten and the sands occur as a narrow fringe on each side of the Alluvium south of Burwash. In a quarry by the roadside south of Burwash the shelly bed, three inches thick, occurs six feet above the top of the sands.

A junction section south of the stream, in a wood north of Hutching's Farm, is interesting from showing *three* layers of shelly bed. The section is as follows:—

		Ft.	In.
Wadhurst Clay.	Shale and Clay	3	0
	"Shelly bed"	1 in. to 0	2
	Shale	0	7
	"Shelly bed"	1 in. to 0	2
	Shale	0	8
	Shelly bed	4 in. to 0	7
	Shale	5	0
Ashdown Sand.	Conglomerate	0 in. to 0	1
	Shale and Shaly loam	1 ft. to 2	0
	Sandstone	6	6

In a quarry in the upper beds of the Ashdown Sand, west of Penhurst Church, one of the beds is soft enough to be dug for sand.

Tilgate stone in the sands has been quarried near the south-western corner of Brightling Park. It also occurs near Ashburnham Furnace.

In a quarry north of Darvel Hole there is a three-foot bed of dark clay with thin clay-ironstone at the top, and further north more of this clay is seen in the sands.

In many places over the Ashdown Sand area some sandy pipe-clayey beds are seen, sometimes the clays are mottled. Several such beds are exposed in the stream near the *worth* of *Passingworth Wood.* Occasionally there are thin beds of shale, more nearly resembling Wadhurst Clay in appearance; as for instance in the stream east of Hole Farm, north of Cross-in-hand, and at the faulted inlier at Froghole.

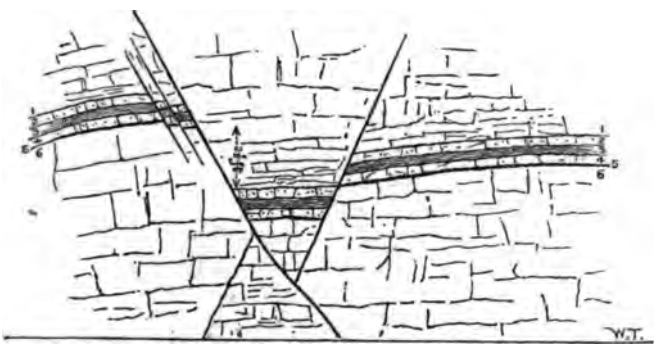
The lower part of the Ashdown Sand of the Brightling district is much more clayey than the upper part. This represents the Fairlight Clays of the coast section, which have only been separately mapped in the neighbourhood of Hastings. It is difficult to estimate the exact thickness of strata between the Wadhurst Clay and the Purbecks, as the lower boundaries are there faulted, and the dips are variable, but it can scarcely be under 400 feet.

Lignite is frequently found in these sands. It has already been noted on the coast west of Bexhill, and on p. 347 will be found a note of the discovery, made in 1801, of "coal" in a stream east of Waldron,* which caused much discussion at the time. In the stream east of Passingworth several thin beds of lignite are seen, generally intermingled with clay; the clay and lignite together are sometimes a foot thick.

A hard, ferruginous, gritty sandstone is dug for roads in the woods near Little London (south of Cross-in-hand); this weathers quite soft and dark on the outside.

At Hole Farm, two miles E.N.E. of Framfield, there is a quarry in the top beds of the Ashdown Sand, in which an excellent example of a trough fault is seen.

Fig. 5. Sketch of a Trough Fault at Hole Farm.†



1. Rock-sand, thinly bedded below. 2, 4, 6. Rock-sand.
3. Finely laminated clay. 5. Ferruginous parting.

The conglomerate appears to be pretty constant at the top of the Ashdown Sand. It may be seen at a quarry south of Stone Bridge, near Church Stile and at Street. At the last named place, one mile N.N.E. of Framfield, the conglomerate occurs as scattered pebbles through some three feet of rock-sand, much false-bedded.

In an Ashdown Sand quarry, a quarter of a mile south of Stone Mill, the beds are much false-bedded in a direction 5° west of south.

The following section is from a quarry by the roadside south-west of Stone Mill, three miles west of Mayfield:—

	Ft.	In.
Sandstone	2	0
Loamy sand	1	0
Hard sandstone	1	6
Sandstone thinly bedded	2	6
Hard sandstone	1	0
Loamy sand and thin sandstone	3	0
Hard sandstone	4	0

* This spot is where the road from Theobald's crosses the stream to the west of that place. See p. 347 for a further account of this.

† See fig. 48, p. 238, for explanation of this fault.

In a small wood (Rocks Wood), about midway between Green Farm and Woodreed, there are some fine natural rocks about 30 feet high, probably formed by the top beds of the Ashdown Sand, but the geology here is somewhat obscure. Clay is seen in the fields above the rock-beds, and a saw-pit, near the stream to the south-west, showed shale; both appear to be Wadhurst Clay, the latter let down by a fault. The joints of the rock-beds run 5° south of east, and are crossed by another series running 5° east of south. At one spot the figures "1727" are cut in the rock; if really of that date they would show this rock to stand the weather well, as the marks are very distinct. These rocks are continued down the valley towards Stone Mill.

WADHURST CLAY.*—This division of the Hastings Beds consists of alternations of clay, shale, and sand-rock, and also contains beds of fossiliferous limestone, of calcareous sandstone or grit, and of clay-ironstone. The latter was formerly extensively worked for the production of iron, and indeed, it was from these beds that nearly the whole of the iron smelted in this part of Sussex was obtained.

There are several layers of the ironstone, but its principal horizon is at a short distance above the Ashdown Sand. It occurs both in the form of small nodules, and in tabular masses, and is usually invested by a number of thin concentric coatings of exfoliated hydrated peroxide; specimens from different localities vary much in appearance upon fracture, but it is usually a smooth stone, of light grey colour, and of high specific gravity. The thickness rarely exceeds four inches.

It seldom contains fossils, but I have occasionally found species of *Cyrena* included in the poorer varieties.

Another kind of iron ore which I have never seen in situ, but of which I have picked up large detached masses in the beds of streams, consists of agglomerations of ferruginous casts of the shells of species of *Cyrena* and *Paludina*.

Associated with the ironstone are several thin beds of limestone, composed in great part of the remains of *Cyrenæ* and *Paludinæ*, these are in many localities known by the name of the "*mine* "*greys*" and were formerly extracted with the iron ore, for the purpose of being used as a flux.† As they do not occur in any abundance they are seldom specially sought for now.

Not the least valuable product of the Wadhurst Clay is the hard calciferous sandstone, or grit (Tilgate stone of DR. MANTELL) which occurs at irregular intervals throughout the series, either in large detached rounded masses or in continuous layers, and which is quarried in several localities on account of its excellence as a road material. I have never seen it in situ of a greater thickness

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* From MR. C. GOULD'S MS.

† This is the bed spoken of above as "shelly-bed."

than three feet and a half, but there are masses upon the shore near the east end of the marine parade at Hastings which exceed five feet.* It is usually of a light blueish grey colour, and not very coarse grained, but occasionally passes into a conglomerate of large rounded pebbles.

The Tilgate stone and the sand rock, are sometimes ripple-marked.

The great mass of the Wadhurst Clay is made up of clay, loam, shale, and sand-rock, in very varying proportions, and the total thickness is rarely less than sixty, or greater than one hundred feet.

The Wadhurst Clay is remarkably rich in fossils, and a diligent search will in most cases be repaid by the discovery of the remains of Plants, Molluscs, Fish, and Reptiles. Bones of the latter occur in the shales themselves, in the sand-rock, and often in great abundance in the calciferous grit.

Among the localities from which specimens have been obtained by Mr. J. Cotton, formerly Collector to the Survey, and myself, are:—the Cliffs east of Hastings, and behind the church at St. Leonard's, the Black Horse quarry at Telham Hill,† quarry at Rose cottage near Hollington, road cutting at Tivoli, railway cutting north of Battle, &c., &c.

The following is an approximate list of their organic contents :—

Equisetites Lyelli, Mant.	*Cyrena parva*, Sow.	*Turtle bones?*
Endogenites erosa, Mant.	*angulata*, Sow.	
Lignite.	——— sp.	
Cypridea tuberculata, Sow.	——— sp.	
„ *valdensis*, Sow.	——— sp.	
„ ——— sp.	*Unio* ——— sp.	
Estheria membranacea, Sow.	*Hybodus*, teeth and defences.	
Paludina fluviorum ? Sow.	*Lepidotus Mantelli*, Ag.	
„ *Sussexiensis* ? Mant.	*Crocodiles*, teeth and bones.	
	Iguanodon „ „	

C. Gould.

On the coast east of Hastings, the exposures of this bed have been noticed in describing the Ashdown Sand. Behind the castle at Hastings there are some 10 feet or so of clay and shale, capped by a little sand dipping S.W.; it is best seen in a road-cutting by the pond. This is probably Wadhurst Clay, faulted down against the great mass of Ashdown Sand, on which the castle stands.

The clay, containing some ironstone, can be traced along the road, northwards, towards the windmills; but the south-westerly dip of the beds being greater than the fall of the ground brings up, first, thinly bedded sandstone, and next the thick bed of rock-sand; a succession precisely similar to that seen on the face of the East Cliff. Further to the north the larger mass of Wadhurst

* "I think it probable that these nodules have been formed by deposits of calcareous matter, concreting the sand together in its original planes of stratification."

† See p. 63 for a detailed account of this quarry.

Clay comes on. The fault by which these beds are thrown is seen in a small hollow on the face of the Cliff, a little west of Ecclesbourne; it trends 50° N., with a downthrow of 30 feet, and strikes out to sea about E.S.E. The soft sand-rock on its south face has been hardened into a crust of quartzose sandstone, on which slickensides can be distinctly traced, and from these it would appear that the beds have not slid vertically but almost horizontally westwards.

This fault appears to enter the Hastings valley by the small hollow just east of All Saints' Church; the line of rocks seems to be there interrupted and to be continued on to the north at a lower level.

At the west end of Bopeep tunnel the clay contains some Tilgate stone with casts of *Paludina* and also a little clay-ironstone.

In the neighbourhood of Rye "the Wadhurst Clay series consists of dark brown or blue shale or clay, probably about 100 feet thick, with a little sand and calcereous grit in it. The lowest beds, which are always clay, are seen capping the Ashdown Sand at the steps at the south-west point of Rye, at Boon's Hill and Thorndale Farm. There is a bed of sand in this division about 30 feet from the bottom. It is seen in the low cliff opposite East Guildford Church just north of the fault, and consists of 11 feet of loamy sand with a little ferruginous matter. From thence towards Iden it crops out, and coming in contact with the Ashdown Sand the position of the faulted boundary is rendered obscure." *

The Wadhurst Clay near Icklesham has a good deal of sand and sandstone in it. The sand occurs with a well marked feature all round the mill west of Ashes; there are perhaps 20 feet of it, with 25 or 30 feet of clay between it and the top of the Ashdown Sand. The sand is seen again half a mile west of Icklesham Church. The sand and sandstone capping the East Cliff, Hastings, seem to be on this horizon. There is ferruginous sandstone in the clay just north of Hole Farm, Northiam.

On the south of Brede Bridge a quarry, open in April 1869, showed clay containing Tilgate stone, five feet or more in thickness dipping to the north-east. The stone contained a great number of shells, including two species of *Paludina*, and some wood. Some of the stone is much decomposed, into a dark ferruginous sandstone.

A little to the south is a small quarry showing a junction of Wadhurst Clay and Ashdown Sand, the latter having a little conglomerate at the top, in places. There is probably a fault between the two quarries with a downthrow north, which brings the clay down to the Alluvium.

Tilgate stone is also seen in the Wadhurst Clay just east of Brede, in Broadland Wood, and on the north-east of Sedlescomb.

The junction of the clay with the Ashdown Sand is seen in several places.

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* F. Drew, *Mem. Geol. Survey*, Sheet 4, p. 5.

By the road-side half a mile east of Brede Church there is this section :—

	Ft.	In.
Clay and shale, with some clay-ironstone.		
Sandstone; fine grained and hard, with a thin parting of shale	1	6
Shale; with lenticular beds of clay-ironstone - - -	5	0
Sandstone; with 6 in. of conglomerate, a little fine grained sandstone above the conglomerate, and sometimes thin partings of sandy clay in it.		

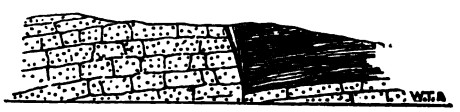
On the east of Broadland Wood clay and shale rest on rock-sand rather coarse at the top. There are "mine-pits" in the clay here.

A little north-west of Gate Farm there is a soft brown sandstone in the clay, which is probably decomposed calcareous grit (Tilgate stone). On the west of Hole Farm there is clay-ironstone just above the Ashdown Sand, and a little above that is a bed of Tilgate stone.

In the road south of Yew Tree Cottage, near Westfield, the beds at the junction dip sharply to the north at about 35° or 40°, but flatten rapidly further south.

A very good example of a fault is seen in one of the cuttings on the South-Eastern Railway west of Hollington Church. Wadhurst Clay is thrown down against Ashdown Sand.

*Fig. 6. Fault in Railway cutting, west of Hollington.**



Wadhurst Clay forms the surface of the land over a great part of the country north and north-west of Bexhill. Red clay is seen in many places about here.

On the south-west of Bexhill the Wadhurst Clay forms the foreshore for some distance west of the outcrop of the Ashdown Sand. It consists of blue and brown shale and clay with some clay-ironstone.

The Black Horse quarry, on Telham Hill, 1½ mile south-east of Battle, is sunk in the Wadhurst Clay for calcareous grit. Mr. W. Boyd Dawkins has furnished me with the following note of it †:—

	Ft.	In.
"Surface soil - - - - - - -	1	0
Rust-coloured grey and white shales with indurated layers -	3	0
Rust and slate-coloured shales with ironstone - -	3	0
Rust and slate-coloured shales without ironstone (*Cyrena*) -	6	0
Slate-coloured shales with layers of a lighter colour (*Cyrena* and Plants) - - - - - - -	3	0
Shale and clay (*Cypridea, Cyrena*, and vegetable matter) -	3	6
Grey Clay with nodules; the "bone bed" [0″–4″] in its lower part - - - - - - -	2	0

* From a sketch by Mr. Aveline.

† This section has been described by W. R. and H. Binfield, *Quart. Journ. Geol. Soc.*, vol. x. p. 175. *Paludina* and insect remains are there noted from the shales.

	Ft.	In.
Calcareous Grit [Tilgate stone], fine grained and hard, dug for roads - - - - - - - -	2	6
Calcareous Grit [Tilgate stone], blue on the unweathered surface - - - - - - - -	2	0

"The beds of Calcareous Grit are ripple-marked and contain remains of Ganoid fish and *Cyrena*.

"The great feature of this quarry is the bone-bed, from which vast quantities of the remains of the animal life of the period have been obtained. It is composed of a mass of coprolites, bones, teeth, scutes, and ganoid scales of irregular thickness. It is conglomeratic in character and contains pebbles of white quartz, which vary in size from a pigeon's egg to a pea, and are all much worn and highly polished. Very few of the organic remains are perfect, but the great bulk of them have been reduced to the condition of pebbles. The only perfect bones that have been found consist of the hard and solid phalanges of the larger reptilia. The enormous femora have been reduced to the condition of fragments. The following is a list of the remains which I have been able to determine :—

Megalosaurus, teeth and bones.
Iguanodon, teeth and bones.
Goniopholis crassidens, teeth.
Teleosaurus, teeth.
Leiodon, a stout, smooth tooth, without striæ.
Plesiosaurus? teeth.
Chelone, fragments of carapace.
Pterodactylus, bones.
Ganoidea, large smooth rhomboidal scales and rounded Pycnodont teeth.
Hybodus, a small striated dorsal spine.

"In the interior of one long dinosaurian bone there were fragments of jet; and also in the groove between the body and lateral processes of the ungual phalanges of Iguanodon. Two of the latter bones are those belonging to the mid-digit which DR. MANTELL has figured by mistake as the fossil horn that grew on the snout of that dinosaur.* The condition of all these remains is precisely identical with those from the crag 'coprolite' beds, and the bone-beds of the Rhætic and Carboniferous rocks. There can be no reasonable doubt about the conditions of deposit being the same in all; with this difference only, that the Wealden bones were deposited in a lake or large river of fresh-water, instead of in sea or an estuary."

The following section, from MR. GOULD'S notes, is of a well sunk close to the second milestone on the west side of the old North road from Hastings :—

	Ft.	In.
Stiff clay - - - - - - - -	4	0
Shale - - - - - - - - -	12	0

* [PROF. OWEN has shown, from a fine specimen of the Iguanodon, discovered by Mr. BECKLES and now in his collection, that this so-called "horn" was really a spur.—W.T.]

	Ft.	In.
Limestone, in two layers	1	6
Friable sand-rock ("gravel")	3	0
Blue shale, with three inches of clay-ironstone	? 15	0
Shale, with some grit and ferruginous grit	11	0
Also containing three or four layers of "Bubble" of from two to three inches in thickness.		
"Blue Rag" (Tilgate stone) in two beds	2	6
Hard sand-rock	1	0
"Blue Bind" (hard shale)	1	0
"Bubble" (hard white clay rock)	0	8
"Blue Bind"	1	0
"Bubble"	0	8
"Blue Bind," with slaty rock and Tilgate stone	2	8
Strata, no account received	9	0
	65	0

White sand-rock below, probably the top bed of the Ashdown Sand.

Red clay is seen in the railway cutting under the sandstone east of the Powder Mills, and at the bridge south-east of this; at the Parsonage there are some thick beds of black shales, with shaly clay-ironstone, interstratified with beds of hard calcareous grit.

A well at the Brewery, Battle, sunk 60 feet in shale, passed through a bed of Tilgate stone, two feet thick, at 40 feet from the surface. In other wells at Battle similar stone was met with.

In the stream east of Dyke's Farm, north of Penhurst, the shale contains several thin layers of limestone, with a little clay ironstone.

A well at Ashburnham Place is 62 feet deep, all through Wadhurst Clay, with a few inches of rock. In a shallower well at a cottage north of the parsonage there were a few thin beds of sandstone, full of fossils.

Clay-ironstone has been dug almost everywhere throughout this district near the lower part of the clay.

At Eason's Green a well was sunk 61½ feet in "Marl" (shale) without passing through any hard bed. The water, which was good, probably came from the top beds of the Ashdown Sand.

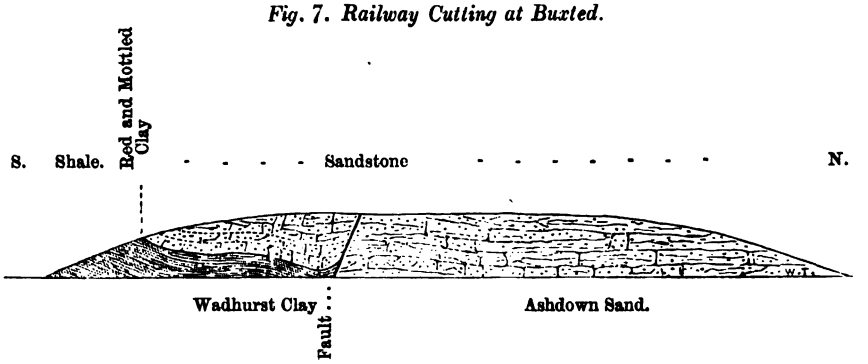
Two miles east of Framfield, south of Stone Bridge, the junction is well exposed:—

		Ft.	In.
Wadhurst Clay.	Shale	6	0
	Shelly bed	0	2
	Sandy shale	0	10
	Shale	1	0
	Loam	0	7
Ashdown Sand.	Rock-bed, with conglomerate at top.		

The shelly limestone is not constant, and appears only in patches. It is sometimes replaced by nodules of clay-ironstone.

The cutting south of Buxted Turnpike Gate, shows Ashdown Sand faulted against Tunbridge Wells Sand on the south; close by this fault the Wadhurst Clay comes out from beneath the sand.

Fig. 7. Railway Cutting at Buxted.



The Tunbridge Wells Sand here consists of alternations of hard and soft sandstone. The Wadhurst Clay is rather sandy at top, but becomes stiffer, red mottled and green, below. The shale contains *Cypridea*. The dip south of the fault is northerly, 3° or 4°; north of the fault the beds flatten.

In the cutting at Hempsted there are thin layers of Tilgate stone in the shale.

Red clay is very commonly found at the top of the Wadhurst Clay. It may be seen around the outliers near Burwash. There is also a good deal of it along the junction between East Hoathly and Little Horsted. The succession of beds at the former place is given on p. 68; here there is a thin bed of sand near the top of the Clay.

There is no direct evidence afforded in this district as to the exact thickness of the Wadhurst Clay. A well at Little Breadhurst, 3½ miles N.E. of Heathfield, passed through 75 feet of shale, and was bored to a further depth of 35 feet. The water thus obtained probably came from the top of the Ashdown Sand. The surface is not far below the top of the Clay, so that 120 feet would be the outside thickness here; it probably varies from 100 to 140 feet.

TUNBRIDGE WELLS SAND.—This division occupies but a small space in the neighbourhood of Hastings. There are no data hereabouts from which its thickness may be inferred. On the west, where it passes under the Weald Clay, it seems to be about 140 feet; on the north-east it must be 150 feet or more. The sands around St. Leonard's Green, Bohemia and Warrior Square, belong to it. The beds in the Cliff between Warrior Square and the White Rock have been described by DR. FITTON.*

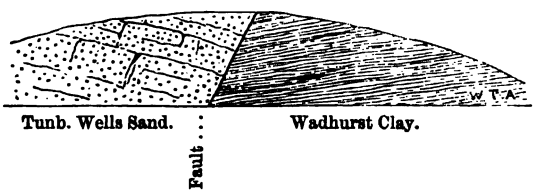
"A section of the Tunbridge Wells Sand, thrown up in the form of an arch, is exposed in the new road, near Hoad's Wood, a mile

* *Trans. Geol. Soc.*, sec. 2, vol. iv. p. 164.

north of Hollington. At the lodge the beds dip N. 30° to 25°, they then, a little to the north, roll over. The Wadhurst Clay comes up to the surface in the centre of the arch. Above the *d* of *Lodge* some of the beds of sandstone contain quartz pebbles. North of the house, below the words *Hoad's Wood*, there are thick and thin beds of sandstone and some shale, dipping S. 30° E., at an angle of 16°.

"A fault was seen in a cutting by road side north of Tivoli Gardens, a downthrow north.

Fig. 8. *Sketch of Fault north of Tivoli Gardens, near Hastings.*



"This section is now obscured. It is about 40 yards south of the turnpike gate (not marked on the map) on the east side of the road." *

On the north-east of Hastings the great mass of sands around Peasemarsh and Beckley belong to the Tunbridge Wells Sand; being brought against the Ashdown Sand on the south by a fault, the exact line of which is uncertain.

There is some red and mottled clay seen in the sand just south of Four Oaks, one mile east of Beckley. A little west of Four Oaks some loamy sand is dug for bricks; this is only a little way up in the sand.

On the south and south-east of Battle there are many sections in railway and road cuttings. The following section was seen (May 1869) in the road ⅓ mile south of the *P.* of *Battle Park.*

At the top of the hill is sand and sandstones, with two or three feet of mottled clay. Further down, at the bend of the road, there is:—

	Ft.	In.
Clay and loam	6	0
Soft yellow and white sand, rather coarse	1 ft. to 2	0
Hard ferruginous sandstone	4	0
Blue clay	3	0

These beds are apparently faulted, but the section here is indistinct; lower down the hill the following beds are seen, with a dip of 3° N.:—

	Ft.	In.
Sand, with a thin band of hard ferruginous sandstone at bottom	5	0
Thinly-bedded sandstone, sandy shale and shale	20	0
Soft sandstone	2	0

* From Mr. Aveline's notes.

	Ft.	In.
Hard sandstone - - - - - -	2	6
Irregularly bedded sandstone - - - - - -	5	0
Hard yellow sandstone - - - - - -	2	6
Slate-coloured loam - - - - - - -	2	6
Hard sandstone. The upper 12 inches are irregular in appearance but hard; all more or less infiltrated with iron -	6	0
Clayey loam, with a bed of sand and sandstone, 0 to 12 inches thick, two or three feet down - - - - -	8	0

In the railway cutting there are 40 or 50 feet of sand-rock; occasionally in tolerably massive courses, but for the most part broken up, fissile and clayey. Red clay is seen below; this is the top of the Wadhurst Clay.

Thick-bedded light brown sandstone is quarried three-quarters of a mile south-west of Battle Church.

The Tunbridge Wells Sand on the south-west of Battle occurs in separate outliers, many of them of small size. The beds are mostly thinly bedded sandstones.

The junction with the Wadhurst Clay is exposed along the road north of Hill Top; here the beds are flat. There is one thick bed of sandstone, the rest are thin.

A good section is seen just north of Bexhill, on the road to Sidley Green.

At Pepplesham Farm, east of Bexhill, there are some rather thick beds of white sandstone. This is probably a small outlier of Tunbridge Wells Sand, let in by faults, or it may be a bed in the Wadhurst Clay.

In the lower part of the sands at East Hoathly there is some clay. The general succession here, as worked out by DR. C. LE NEVE FOSTER, is as follows:—

		Ft.
Tunbridge Wells Sand.	Sand - - - - -	
	Mottled clay ("Catsbrain") - -	3 to 4
	Sand and rocksand - - -	14
	Stiff red and blue clay - - -	5 to 6
	Sand - - - - -	? 20
Wadhurst Clay.	Stiff clay, red in places - - -	6 to 10
	Sand - - - - -	4 or 5
	Clay, red at the top - - -	

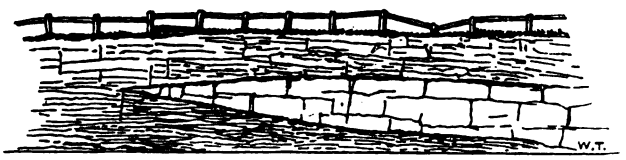
Red clay is seen in the sand in places further west, and it is possible that this may represent the Grinstead Clay. The fault which passes just on the south of Little Horsted renders the succession here somewhat obscure.

It was after this place that DR. MANTELL named the highest division of the Hastings Sands ("Horsted Beds"); the sections in the road here have been described by him.*

* Fossils of the South Downs, p. 25; and Geology of the South-east of England, p. 191.

By the roadside a little east of Hadlow is a quarry, showing about 13 feet of sand and sandstone. A good example of the inconstant character of these sands is seen here. The thinly-bedded sandstone which occurs at the west end of the quarry is replaced at the east end by a thick bed of hard sandstone.

Fig. 9. Sketch in Quarry, near Hadlow.



The dip in this quarry is to the east about 7°, but a little further west a westerly dip is seen. There seems, therefore, to be a small anticlinal here. The main line of watershed connecting the Crowborough and Brightling anticlinal lines passes just to the east of Hadlow (see p. 160).

CHAPTER V.—HASTINGS BEDS, *continued.*

2. Cranbrook and Tunbridge Wells District.*

The area which we now take in hand touches that last described on the south. From Rotherfield its boundary passes north-west, skirting the eastern part of Ashdown Forest, to the Medway at Ham Bridge. This river then becomes its western boundary.

This district, like the last, has a central area of high ground formed generally of sandy beds; but in this case the rocks are Tunbridge Wells Sand. There is no very strongly marked anticlinal line traversing the district to which this high ground is due. As a whole, however, the beds dip northerly to pass under the Weald Clay on the north, whilst on the south of the high ground the dip is less constant, and the beds here are traversed by several rolls, not continuous for any long distances.

The beds will generally be described from east to west.

Ashdown Sand.—The area occupied by this formation is not large in the district now under consideration. At the eastern part it occurs in the deepest valleys, just fringing the alluvium. In the north it occurs in two inliers, one at Goudhurst, and one, much larger, on the north and north-east of Tunbridge Wells. On the south it often forms rather high ground, but nowhere covers very much space. The thickness exposed in this district, excepting near Ashdown Forest, is probably not much over 100 feet.

The Ashdown Sand consists of sandstone with many interstratifications of loam and clay. The sandstone is very soft and fine-grained, of a buff or white colour; the loam is of a grey or brownish grey colour, sometimes yellow, and again at times nearly white. The clay, especially when in any thickness, is a blue shaly clay. The sandstone is in beds of a foot or two thick, generally with about equal parts of loam between them.

The upper strata very generally appear as massive rock-beds; often coarse or even conglomeratic in the highest part. This may be seen in very many places along the line of outcrop, some of these localities are noticed under the head of Wadhurst Clay.

A short way below the junction there are frequently one or more layers of hard calcareous sandstone, "Tilgate stone."

"At Stone Cliff, a little west of Knock House, seven feet of rock sand are exposed, and beneath this three feet of calc-grit, which is dug for roadstone.

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* In this chapter I have made much use of the note books and field maps of Mr. F. Drew and Dr. C. Le Neve Foster.

"At Reading Street, near where the old barracks stood, there is a layer of very hard calcareous grit."*

In the stream half-a-mile north of Ashenden there is 18 inches of calc-grit which decomposes into a ferruginous sandstone.

The narrow line of Ashdown Sand on the west of Bennenden is brought against the Tunbridge Wells Sand by a fault. The top beds are seen at Babb's Farm. Immediately below the Wadhurst Clay there is half-an-inch of very coarse sand, which here represents the conglomerate.

At the inlier near Goudhurst the top beds are frequently exposed, and also at the small faulted inliers at Hoathly and Sandhurst Farms. At the latter place 15 feet of rock-sand and sandstone are seen.

Good sections of the Ashdown Sand are seen in the railway cuttings between Tunbridge and Tunbridge Wells.† The cutting at Goose Wood shows the top beds underlying the Wadhurst Clay; further north, just south of the Tunnel, there is this section:—

	Ft.	In.
Sandstone	4	0
Loam	8	0
Sandstone	5	0
Sandy Clay	2	0
Sandstone	3	0
Sandy Clay	8	0
Sandstone	4	0
Shale	8	0
Sandstone	6	0
	48	0

Returning now to the southern part of our district we take up the beds at the Rother, near Bodyham, and trace them westwards.

Ashdown Sand underlies the gravel at Bodyham promontory, and is exposed in the road, near the church, where some rather "catsbrainy" clay is seen in the sands with a rock-bed beneath.

The road south of Beechouse Farm, north of Salehurst, gives a section of the upper part of the sands, not far below the Wadhurst Clay:—

	Ft.	In.
Thinly bedded yellow sandstone	2	0
Loamy sand	2	0
Thinly bedded yellow sandstone	5	0
Soft loamy sandstone	2	0
Hard sandstone	5	0

The dip here is about 2°, a little to the west of north.

The sands border the alluvium nearly to Etchingham, and then, with some irregularities owing to faults, they rise, nearly with the rise of the ground, to the north-east, attaining a considerable height at Stone Gate. The stream flowing down from

* DREW, *Mem. Geol. Survey*, Sheet 4, p. 5.

† The sections along this railway are described by MR. PRESTWICH and PROF. MORRIS, *Quart. Journ. Geol. Soc.*, vol. ii. p. 397 (1846). See also DR. MANTELL, *Ibid.* p. 95. MR. DREW's paper in vol. xvii. of the same Journal gives a description of the entire district. DR. MANTELL also described the neighbourhood of Tunbridge Wells in BRITTON'S *Guide*, 1832.

Stone Gate to near Barehurst gives an almost continuous section of the junction beds for nearly a mile. The fall of the stream and the dip of the beds being the same.

The conglomerate appears to be tolerably constant at the top of the sands. It is seen at Conghurst Farm, and in the following section at Cold Harbour:—

		Ft.	In.
Wadhurst Clay.	Shale		
	Shelly Bed	0	4
	Shale	3	0
Ashdown Sand.	Quartzose conglomerate	2 in. to 0	3
	Rock sand (shattery)	0	9
	Sandy and shaly loam	1	6
	Sandstone	2	0
	Ferruginous sandstone	1	6
	Sandstone	4	0
	Ferruginous sandstone and loam	1	0
	Sandstone	5	0

In a quarry ¼ mile S.W. of Lt. Gibsreed, the conglomerate is eight inches thick. At the *i* of *Cinder Bank* the pebbles are somewhat coarser than usual.

The railway cuttings south-west of Wadhurst afford some interesting sections of the sands. That south of Scrag Oak has some thin beds of shale near the top of the sands, with a little sand in the clay, so that the junction is somewhat less distinct here than usual.

At Snape Wood there are several beds of clay-ironstone in the sands which have been worked for ore since the railway was made; one bed varies from six to eight inches in thickness, another 12 inches, the third is less constant, but sometimes attains a thickness of 18 inches.*

Ironstone is also seen in the stream in Snape Wood, and in the waste-heaps from Wadhurst Tunnel.

On the north of Snape Wood there is some white and orange coloured pipe-clay in the sands.

The rock-bed is exceedingly well developed on the north of Mayfield, and forms bare rocks in some places, especially so about Trodger's and Little Spitly Farms. The "Gills" here, worn deeply into the rock, with the stream tumbling over the upper beds, are not inferior in beauty to the well known "Old Roar" at Hastings.

A quarry by the road-side, just north-east of Coggingsmill Street, gives a section of the upper beds, of which the following is a detailed description:—

	Ft.	In.
White sand	2	0
Rock-sand, sometimes thinly bedded	10	0
Rock-sand	7	0
This bed varies much in different places.		
White and yellow sand	1	0
Pale yellow sandstone, very ferruginous in some places	4	0
Greyish yellow sandstone	3	0
Loamy sand	0	8
Hard yellow sandstone	6	0

* A note of these workings, by Dr. C. Le Neve Foster, will be found on p. 337. The beds worked appear to have been thicker than any seen in the cutting.

The beds here are traversed by wide joints, into which the shale from the Wadhurst Clay has been let down. The exact junction is not seen.

The rock-bed is well seen in the small inliers north of the road from Mark Cross to Wadhurst, and generally over the outcrop around Rotherfield.

WADHURST CLAY.— This clay does not differ in character from that of the Hastings district, and the general description there given will serve here (see p. 60). Its thickness, however, is somewhat greater here, being 160 feet at Pembury, as proved by a well at Pellat Gate; whilst near Gondhurst it is probably 180 feet.

Sections in the main mass of the clay are infrequent; not many occur at the top junction, but sections showing the junction with the Ashdown Sand are common enough; some have already been noticed in describing that division.

The Wadhurst Clay takes up a considerable area in the Cranbrook and Tunbridge Wells district, far more than in either of the other districts into which we have divided the Hastings Beds area; but it nowhere makes a wide and continuous expanse, being either capped by outliers of Tunbridge Wells Sand, or having its valleys cut down to the Ashdown Sand. Between Tenterden and Rolvenden it takes up some space, and passing eastwards towards Cranbrook, it narrows northwards down the valleys, passing gradually under the Tunbridge Wells Sand in that direction. On the north of Lamberhurst there is a considerable area of clay land; and again on the south of Tunbridge. On the east, west and south of Wadhurst, there is a large extent of country occupied by this division; whence its name.

"Marl pits" are frequent throughout the clay country, as are "mine pits," near the Ashdown Sand outcrop. Calc-grit (Tilgate stone) sometimes occurs in the clay, and when of any thickness is often dug for roadstone. Sand beds, too, occur, but none of much importance.

Calcareous sandstone (Tilgate stone) is the most valuable product of the Wadhurst Clay, now that ironstone is no longer dug.

It occurs in a gill on the south of Palstye Court, and with some sandstone, in the north-west of High House: both of these places are in the Isle of Oxney. To the north-west of Ashenden it occurs with some clay-ironstone, about 10 feet above the bottom of the clay and is there said to be from one to two feet thick. A quarter of a mile south of The Fostal it is found about six feet above the junction; and in the "gill" west of that place are several layers of grit with some ironstone in shale, succeeded below by the "shelly bed" and, still lower, by the top beds of the Ashdown Sand.

At a quarry about a quarter of a mile W.N.W. of Bennenden Church the grit is dug for roads; here it is from 1½ to 2½ feet thick.

Calc-grit is seen in the road on the south of Hexden Bridge, just north of the cross-roads.

A very hard siliceous calc-grit has lately been found near the bottom of the clay at Lamberhurst, about half-a-mile east of the Church.*

The following are some notes of sand-beds in the Wadhurst Clay:—

"A sandy bed, underlying clay, is seen about a mile west of the village of Stone, and a sandy stratum, apparently the same, crops out on the brow of the hill above Reading Street."† This bed is seen at several places on the road to Tenterden.

About three-quarters of a mile S.S.E. of Kench Hill, S.E. of Tenterden, there is a four-inch bed of ferruginous quartzose conglomerate; this is about 25 feet up in the clay.

A quarter of a mile north of The Fostal a rather ferruginous shaly sandstone is dug for roads; it is about 3½ feet thick.

On the east of Palsty Court some six or eight feet of sandstone occur in the Wadhurst Clay.

Just north-west of Boar's Nest, north of Salehurst, there is some blackish sandstone exposed in the valley, which might be mistaken for an inlier of Ashdown Sand, but it is in the Wadhurst Clay.

Beds of sand are seen in the streams west of Hammerden and south of Mapesden (south of Wadhurst), where the beds are very thin. In the cutting south of Best Beech Hill Tunnel (Wadhurst Tunnel) there is sandstone, 15 feet thick, rather irregularly bedded. Several of the beds contain casts of *Cyrena*. At Comb Wood there is ferruginous sandstone and loam.

The "shelly bed" is seen in many sections from about Hawkhurst, westwards. At the small outlier at Conghurst Farm, one mile south-east of Hawkhurst, it is two inches thick, three or four feet above the sands. At Cold Harbour it is four inches (see p. 72), near Little Gibsreed it is four inches thick.

A stream-bank three-quarters of a mile north-east of Bennenden Church shows a good deal of dark blue shale with a layer of good clay-ironstone in nodules; also two layers, 1 inch or 1½ inches thick, and about 12 inches apart, of soft calcareous stuff containing *Cyrena*. This section is a good way down in the clay and may perhaps exhibit the lower beds.

On the south of Tenterden and Bennenden the "shelly bed" seems to be very constant just above the junction. It also occurs pretty generally along the outcrop south of Wadhurst and Ticehurst.

The clay-ironstone is very seldom seen, indeed it seems likely that some of the mine-pits were sunk for this thin "shelly bed,"

* I am indebted to Capt. Palmer, R.E., for this note. A specimen of the stone is in the Museum of Practical Geology, to which it was presented by Mr. W. C. Moreland, of Court Lodge, Lamberhurst.

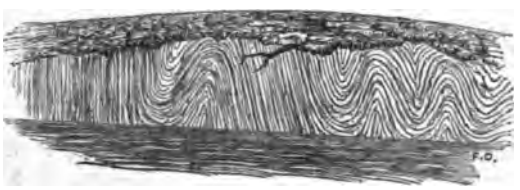
† Drew, *Mem. Geol. Survey*, Sheet 4, p. 5.

but getting at the same time any ironstone that might be present. The shelly bed contains a great deal of iron, as carbonate, and would serve as ore by itself; probably its more general use was as a flux.

The top of the clay is very commonly of a rather bright red colour. It is so all around Tenterden, and from thence westwards to Mayfield, and also near Cranbrook. The junction with the Tunbridge Wells Sand is not usually so sharp as that with the Ashdown Sand. There is sometimes a greenish clay seen when large sections are exposed, but red is the more usual colour.

In the neighbourhood of faults the shale is sometimes much contorted, as is shewn in the following sketch by MR. DREW, taken N.E. of Fright's Farm, near Mark Cross.

Fig. 10. *Stream Section of Shale disturbed near a large fault.*



TUNBRIDGE WELLS SAND.—This division greatly resembles the Ashdown Sand. It has often at its top a bed of rock-sand, and the lower parts so closely resemble in general character the Ashdown Sand that the two divisions cannot be distinguished in section.

There is a subordinate bed of clay which appears to be more constant than any which occurs in the Ashdown Sand. In this district it has not been separately mapped, but in that next to be described, East Grinstead, &c., it is of some importance, and has there been shown by a separate colour on the Geological Survey Maps. It is called Grinstead Clay.

The presence of this subordinate clay renders it necessary to divide the Tunbridge Wells Sand into two divisions, Upper and Lower. At present, however, we will treat the formation as a whole. This is the more advisable as, the lines not having been traced, it is not absolutely certain that the clay seen in this district is always on the same horizon. It is believed to be so, and to represent the Grinstead Clay of the west.

Throughout our present district this clay is generally loamy, nearly always mottled with red, white and yellow; more rarely it is blueish or orange. Occasionally, however, where at all thick it becomes more stiff and shaly; this is its general character about East Grinstead. The mottled variety is nearly everywhere known as "catsbrains."

The total thickness of the Tunbridge Wells Sand is about 150 feet in the eastern part of this district, at Goudhurst; and

about 180 near Tunbridge Wells. The catsbrainy clay is sometimes not more than about 30 feet from the bottom of the sands, that being then the thickness of the lower division; in other places it is 50 or 60 feet up.

The following description refers to the Tunbridge Wells Sands of Sheet 4:—

"The lowest beds in this area are loose sand and loam, and the top bed (as with the Ashdown Sand) is hard rock-sand, not close enough to constitute sandstone. This rock-bed is well seen at a place marked Cherry Garden on the map; and in another sandpit, by the road a little to the south-east, it consists of white sand curiously false-bedded. The same rock is also seen in many places about Kennardington and Warehorn, and often contains thin layers of loam and clay."*

It is unnecessary to multiply sections where there is so little of importance to describe. The following detailed measurements may suffice.

Section in railway cutting north of the Tunnel at Tunbridge Wells measured by MR. DREW:—

	Ft.	In.
Yellow loam	9	0
Sandstone	3	0
Sandy clay	4	0
Sandstone	7	0
Clay	6	0
Sandstone	1	0
Loam	2	0
White rock-sand	6	0
Shaly sandstone	3	0
Sandstone with parting	5	0
Sandy clay	2	0
Sandstone with two partings of clay	7	0
Sandy clay	4	0
	59	0

At the new road cutting, one mile S.W. of Groombridge, the following good section is exposed:—

	Ft.	In.
Loose sand and thinly bedded sandstone	6	0
Sand and sandstone, with some clayey sand	3	0
Yellow sandstone with partings of white clayey sand	1	6
Sandstone in thick beds	6	6
White, yellow and grey sandstone	13	0
White sandstone in hard massive beds, becoming more thinly bedded towards the south	12	0
Yellow, grey and white sandstone with shaly partings	7	0
Hard grey sandstone	2	0
Thinly bedded sandstone	0	8
Hard massive sandstone	3	6
Thinly bedded sandstone	3	6
Yellow and white sandstone, hard, with ferruginous infiltrations	4	0
Grey shaly sand	0	8
White pipe-clayey sand	1	0

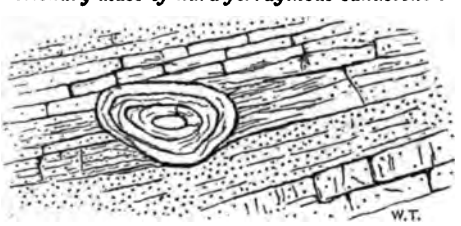
* DREW, *Mem. Geol. Survey*, Sheet 4, p. 6.

	Ft.	In.
Ferruginous sandstone	4	0
Grey sandstone, shattered	5	0
Sand and sandstone, with an irregular hard bed in one place which thins out rapidly	10	0
Shaly sand with a mass of ferruginous sandstone	4	0
White and yellow clayey sand	5	0
Hard white sandstone	1	0
White and yellow clayey sand	3	0
Hard white sandstone	1	0
Clayey sand	3	0
	100	4

The lower beds are very inconstant, and the lowest one passes down into mottled clay, which probably represents the Grinstead Clay. The top beds seen are probably many feet below the bottom of the Weald Clay.

The mass of ferruginous sandstone which occurs in a four-foot bed in the foregoing section (6th bed from the bottom), affords a good example of concretionary structure; Fig. 10. There can be little doubt here that the ferruginous matter has penetrated the bed since its deposition and, by segregating around a central point, has increased the bulk of the stratum, and so pushed downwards the lower and softer bed.

Fig. 11. *Concretionary mass of hard ferruginous sandstone in softer strata.*



A quarry at the curve of the main road half a mile west of Mayfield, exposes a good section of the sands, the details of which are as follows:—

	Ft.	In.	Ft.	In.
Yellow sandstone, broken			3	0
Thinly bedded sandstone, containing—			6	3
White sandstone	1	7		
Ferruginous sandstone	0	4		
Yellow ,,	0	2		
White and yellow sandstone, with thin ferrug. partings; loamy below	2	0		
Ferruginous sandstone	0	2		
Loamy sand	2	0		
Grey sandstone with ferruginous partings			3	0
Hard yellow sandstone			8	0
Ferruginous parting			0	1
Hard yellow sandstone			3	6
Grey sandstone, ferruginous, and thinly bedded (A very variable bed.)			2	0
Good hard sandstone			7	0
Soft sandstone parting			0	6
Hard sandstone			3	0
			36	4

Lignite does not often occur in the Tunbridge Wells Sand; the following are some places where it has been noticed.

A bed, six inches thick, occurs at Tenterden, near the bottom of the Sands.

In a quarry at Mumpumps, 2½ miles E.N.E. of Hawkhurst, there is a bed of carbonaceous clay and shale, with plant remains, two to three inches thick; it is underlain by a stiff brown clay of about the same thickness.

A hard ferruginous sandstone is much dug for road-stone about Flimwell, and also in Frith and Bedgebury Woods. One quarry gave the following section:—

	Ft.	In.
Red and white catsbrainy clay - - -	4	0
Yellow and white „ „ - - -	3	0
White sandstone, soft and of no value - -	2	0
Ferruginous grit - - - - 1 ft. to	1	2

The grit is generally brown on the outside, but sometimes is nearly black. The shell or outer part is mottled when broken, but the inner kernel exhibits a shining crystalline appearance. This layer is called "kernel stone," and is dug for roads.* The bed is often several inches thick, it varies somewhat in appearance and may not occur always exactly on the same horizon in the localities noted above.

The catsbrainy clay is seen in many places around Tenterden. The long fault ranging E.S.E. on the south of Bennenden, and which brings Ashdown Sand and Tunbridge Wells Sand together, has been drawn by the aid of this bed. Near Babb's Farm there cannot be less than 15 feet of it, perhaps 20 feet. A similar bed, perhaps the same, was useful in like manner in drawing the fault east of Mayfield.

The clay occurs frequently over Bedgebury Woods, and here, as well as elsewhere, is often dug for bricks.

The highest beds of the Sands are well seen in the neighbourhood of Tunbridge Wells, they there forming the well-known natural rocks (see p. 246). There is often a conglomerate at or near the top.

Outliers of Weald Clay cap many of these rocks. As the occurrence of such outliers on the Hastings Beds country is unusual, I give here the evidence on which MR. DREW mapped these patches as such—

"From New House, between Withyham and Groombridge, to Sherlocks, the clay is underlain by a thick bed of sandstone; and a little east of the last place, in just the same line of strike, making just the same feature, and capped by similar clay, is a rock-sand which must belong to the same bed. At Forge Farm and Rocks Wood, this bed makes natural rocks, which are known as Penn's and Harrison's Rocks [fig. 49, p. 246.] These rocks continue, with a few breaks, to Eridge Green; where also they are

* Probably this is the bed described by SIR JOHN HERSCHEL, *Quart. Journ. Geol. Soc.*, vol. xxi. p. 421.

capped by clay, and where they are underlain by Wadhurst Clay, which crops out in the valley. Now there is just the same change from sandstone, with clay upon it, to rock-sand, also capped by clay, between the top of Groombridge Hill and the High Rocks; and again, from Lengthington (Langton) Green to Tunbridge Wells Common. These beds must therefore be upon the same horizon. This sand is proved to be the last (highest) important bed of sand in the Wealden, for its first outcrop is from the flat of the Weald Clay at Chiddingfold and other places."*

Other outliers of Weald Clay occur near Cuckfield (see pp. 91 and 102).

On the east of Capel the top beds lose their rocky character. East of Frittenden the boundary is faulted, and the top beds are not exposed. At the extreme east of the district the top is again rocky in some places, as already noted (p. 76).

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* Mr. Drew's MS.

CHAPTER VI.—HASTINGS BEDS, *continued.*

3. East Grinstead District.*

This, the third district into which we divide the Hastings Beds area, comprises most of the western part of that area. Its eastern-central part is occupied by the high land of Ashdown Forest, in which is the highest point of the Weald, Crowborough Beacon, 803 feet. This high land is an anticlinal, or rather it has a quâquâversal dip; for on all sides as we recede from it we pass over higher beds. A considerable area of the Forest is over 500 feet in height, but the surrounding country is all at a lower level than this, excepting perhaps some small areas of St. Leonard's and Tilgate Forests, and a still smaller area at Turner's Hill.

We shall, after treating of the central area of Ashdown Sand, describe the district from the Medway on the north-west by East Grinstead and Balcombe to the long faulted outlier of Weald Clay, which extends east and west on the north of Cuckfield.

Ashdown Sand.—The total thickness of this division exposed in Ashdown Forest exceeds 400 feet, with the base not reached by any of the gills, which are cut deeply into the ground.

The lowest beds exposed are probably those near Crowborough Mill, where there is sand and sandstone with sandy shales containing lignite. The beds do not much differ from the Ashdown Sand of the areas already described.

The great mass of this division is sand and sandstone, often very ferruginous and with some clay-ironstone. There is a subordinate bed of clay of some thickness; and in places lignite occurs, though nowhere in such thick beds as those of the Hastings district (pp. 51 and 59). At the top there is commonly a rock-bed, as in the other districts.

At the south entrance of Jarvis Brook Tunnel, south-west of Sandhill, and 2½ miles W.S.W. of Rotherfield, there is a deep section of the Ashdown Sand, showing altogether about 40 feet of strata. The beds vary, being sometimes in thin layers, and then uniting into thickish and massive beds. Fragments of plants are common, and some of the sandstone is very finely false-bedded with layers of carbonaceous matter. There is also a thin layer of shaly clay. The dip here is 5°, about S. 10° W. One of the winding shafts of the tunnel was 120 feet deep, and passed through sand and sandstone only.

In the cutting just east of Jarvis Brook, there was, in the sandstone, a bed of sandy shale, containing half-an-inch of carbonaceous matter. This same cutting gives an excellent example of the

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* Much of this Chapter is from Mr. Drew's notes.

rapid thinning away of hard beds, such has already been sketched in the quarry at Hadlow (p. 69). In a quarry near Wytch Cross (Honeywell Quarry) there is this section:—

	Ft.	In.
False-bedded sandstone and loam - - - -	20	0
Hard sandy clay - - - - - -	4	0
Black shale - - - - - -	2	0
Fine white and buff sandstone in beds 3 or 4 feet thick -	12	0

The following notes are by MR. DREW:— "Clay-ironstone occurs in several places in the Sands, and is sometimes dug for roads. In the quarry at Wrens Corner there is sandstone, and below that a one-foot layer, consisting of nodular clay-ironstone in the middle, and of brown ironstone outside, the change being perhaps due to weathering; this is called 'kernel stone,' as also is a somewhat similar bed near Hawkhurst (see p. 78).

"A layer of clay-ironstone, five or six inches thick, occurs in a quarry a little west of Hartfield Grove; a few feet above this layer are some nodules of the same: here, too, it is dug for roads. There is clay-ironstone in the stream north-west of Hocklye Plantation.

"In a quarry at Gill's Lap there is a layer, varying in thickness from 6 inches to 2½ feet, of hard ferruginous sandstone or ironstone, dug for roads."

There is some stiff clay on the northern slope of the Forest, north of Steel Cross and eastward to Redgate Mill, at Turks, and south of Summersales. This clay must be in some places at least 30 feet thick, and is underlain by a rock bed. From the apparent absence of red clay in its upper part and of shelly limestone at bottom, it has been considered as a bed in the sands. It could all be taken as Wadhurst Clay, only by assuming some improbable faults. In levelling the Horizontal Section (Sheet 77), which passes over this clay at Summersales, I saw what appeared to be mine-pits near the lower junction. It is likely, therefore, that this western patch of clay may be Wadhurst, let down by faults.

Clay and shale occur further west near Paternoster Row and Claypits Farm, here containing some clay-ironstone. Still further west, at Claypits Farm, south-west of Forest Row, there is a good deal of clay, and again at Walesbeech Farm.

A clay bed is also seen in an inlier north-east of East Grinstead, at Blockfield, and in places east of that.

WADHURST CLAY.—This division is similar in all its characters to the Wadhurst Clay already described (pp. 60 and 73). Its thickness appears to be 120 feet on the south, near Uckfield; and about the same or slightly more on the north, between East Grinstead and Tunbridge Wells.

The shelly bed is very constant at the base of the clay; and "mine-pits," whence this bed and ironstone have been dug, are very commonly found along the lower boundary.

Calcareous grit occurs, but in less quantity than in the eastern part of the district last described. It appears to diminish westwards, as far as the Wadhurst Clay is concerned. At Beech Green, however, 2 miles N.N.E. of Hartfield, it occurs in some thickness, and large quantities have been there dug for roadstone. The grit is in two, or sometimes three layers, three feet thick together, and with it there is some sand.

Thin layers of grit and one of a blue shelly limestone occur in the railway cutting near Horseshoe Farm, S.E. of East Grinstead. There is a bed of sand in the clay, 10 or 12 feet thick near Mill Place, 2 miles south-west of East Grinstead.

As an illustration of the junction in the Uckfield district we may take the following section, from a marl pit by the road side, 2½ miles N.N.E. of Buxted, and due west of Sleeches Farm :—

		Ft.	In.
Wadhurst Clay	Shale.		
	"Shelly bed" - - - -	0	1½
	Hard calcareous sandstone - -	0	1
	"Shelly bed" - - - -	0	2
	Shale - - - - -	10	0
Ashdown Sand.	Rock bed.		

A stream section, 1½ miles north-east of this and just east of Welchwood, showed the shale very much contorted near to an east and west fault.

Red clay is common at the top; and at one place this red clay is shaly, which very rarely occurs. This was at the entrance to the wood N.N.E. of Hendall, 1½ miles N.N.E. of Maresfield.

Lower Tunbridge Wells Sand.—The thickening of the Grinstead Clay in a westerly direction renders it necessary to divide the Tunbridge Wells Sand, as already noticed (p. 75). The thickness of this lower division is generally about 60 feet on the north, but on the south it appears to be over 100 feet.

The town of East Grinstead is chiefly built on this division. In its upper part there is generally a rock-bed which frequently forms natural rocks, as in the valley near Ashurst Wood, S.E. of East Grinstead. It is also seen in many of the road sections around that town.

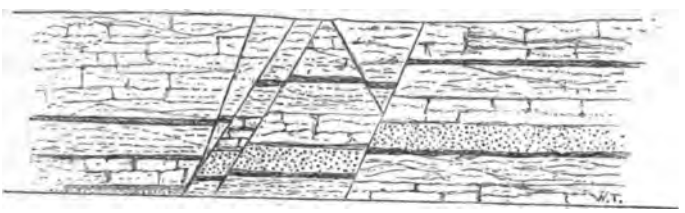
The junction is seen in a quarry east of Grinstead Common :—

	Ft.	In.
Clay and shale - - - - -	4	0
Hard sandstone - - - -	1	0
Parting of sand and sandy clay (thin).		
Hard sandstone, ripple marked - -	5	0

The stone for St. Margaret's Home was dug here. About two feet down in the lower bed a fine specimen of *Lepidotus Fittoni* was found, the head of which is now in the Museum of Practical Geology.

The railway cutting a little south of this quarry affords an excellent section of the rock. The sides of the cutting are smoothly dressed, and stand quite vertically. Several faults are seen here, some of which are shown in Fig. 12.

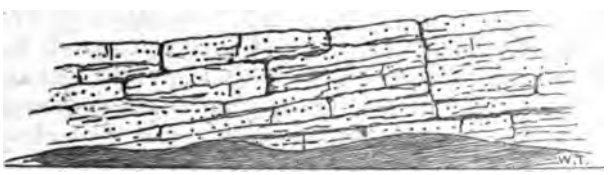
Fig. 12. *Sketch of small Faults, east of East Grinstead Station.*



At the *P.* of *T. P.* (East Grinstead) the south-eastern entrance to the tunnel exposed a good section of the lower junction. The cutting is 38 feet deep, half of which is sandstone, and below that comes Wadhurst Clay. At the junction there is no red clay, but green and blue shale and clay.

In the cutting north of the road there is a junction seen, which exhibits a curious instance of thinning away of beds. If the sandstone were *below* the clay this section might well be taken as probable evidence of unconformity.*

Fig. 13. *Junction Section, showing thinning out of beds.*



The railway cutting† north-west of Salmon's (Ashurst) is in sand and sandstone. For a few yards there is some blue and brown clay brought up by a sharp anticlinal. It may be Wadhurst Clay, as this is certainly very near the bottom of the sands; but the clay contains some thin beds of sandstone, or it may be only a bed in the Tunbridge Wells Sand.

The cutting south of Rickwood's shows Tunbridge Wells Sand resting on Wadhurst Clay. The sandstone is yellowish, and the clay is a blueish and brownish shale and clay; there is no red clay.

The very fine natural rocks which occur around West Hoathly are the top beds of the Lower Tunbridge Wells Sand (see Fig. 51, p. 247). The same bed is also well seen at Balcombe.

The joints in these rocks are often wide, and sometimes contain a great deal of crystalline carbonate of lime. This is seen in a

* Compare this with the sketch of extreme falsebedding in the cliffs east of Hastings, Fig. 3, p. 47.

† Of the unfinished "Surrey and Sussex Railway."

quarry by the roadside south of Hook, West Hoathly; and here is also seen a good section of the coarse conglomerate which hereabouts, and further to the south-east characterises the top of this division. It is about a foot thick, and contains fish-scales and teeth.

Near Philpott's the joints have been so widened out below that they form long cave-like hollows; one such, exposed by MESSRS. DREW and HAY, was of considerable length, and thickly covered with stalactites.

On the east of Paxhill, on the south side of the road, there is a good section of the upper junction:—

	Ft.	In.
Clay - - - - - -	10	0
Conglomerate - - - - -	0 to	6
Hard sandstone - - - -	4	6
Thin parting.		
Hard sandstone - - - -	4	0
Soft ferruginous sand with sandstone - -	10	0

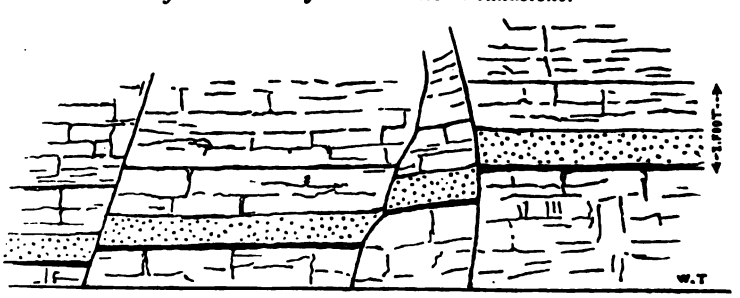
The rock is much jointed, the main joints running N.W. The joints, where wide, are filled with clay, and their sides have much carbonate of lime. There are sometimes small displacements along the joints, with a fall of a foot or so. The dip is from 3° to 5°, 20° W. of N. The top of the sand has a waved and uneven appearance when the clay is stripped off.

The conglomerate which occurs at the top of the sand is very well developed near Lindfield. About a mile north-east of that place by the east side of the road there is a small quarry in which the top beds are well shown. The conglomerate there contains a good deal of white chalky looking stuff, probably derived from the waste of the Portland Beds. I also here found a small fragment of an *Ammonite*, from which we may infer that although the pebbles of the conglomerate are apparently mostly derived from palæozoic rocks, yet that the Wealden rocks were also partly derived from the waste of secondary strata.

The rocks on the west of Uckfield are the top beds of this division, as also are those at Rocks Farm, 2½ miles N.N.E. of that town. A sketch of natural rocks at the latter place is given on p. 247; these run parallel with a line of fault.

On the south of this fault the road section shows some small faults (Fig. 14); the beds here exposed are alternations of rather soft sandstone and sand.

Fig. 14. *Sketch of small Faults in sandstone.*



"In the wood south of Gipps, 3 miles W.S.W. of Uckfield, the Lower Tunbridge Wells Sand is a white and French-white sand-rock, on the top of which there is about six or eight inches of pale-grey sand, containing numerous specks of carbonaceous matter. Above this, which sometimes thins away to nothing, there is an irregular bed, from two to three feet thick, of harder sand-rock, white or of an ochreous or ferruginous yellow and pale chocolate-brown colour, with an undulating surface: above this occurs the first or lowest bed of Grinstead Clay."*

"At a pit in the wood W. of Longford a section was noticed very like that near Gipps Farm. The lowest bed seen was a French-white, soft sand-rock, called "red sand" by the people of the neighbourhood, who say it is the best in the country around for building purposes (for making mortar) on account of its sharpness. Probably this is a part of the Lower Tunbridge Wells Rock, and the clays above are the lowermost beds of the Grinstead Clay. The surface of the sand-rock was more even here than I had ever noticed it to be elsewhere."*

"At a quarry in the wood, on the east of Vixen Grove near Chaily, the Grinstead Clay is seen resting on Lower Tunbridge Wells Sand. The clay below is shaly, of a pale grey colour, but becomes mottled ("catsbrainy") a short distance up. The sandstone on the southern side of the quarry is very regularly jointed and tolerably hard, in beds of from two to four feet thick; the main joints run 10° north of west, the other joints coming nearly at right angles. The dip is $2\frac{1}{2}$°, about 20° west of south. Towards the west the beds bend down about 7° to the west, and seem to be slightly let down by an east and west fault. On the northern side the beds are much softer, and are broken up for building sand." †

"The sandstone is quarried at Colonel's Bank, south of Reedens; it is a good solid stone below in beds of about four feet thick; towards the upper part the rock becomes soft and flaggy. The joints run 10° north of east." †

"The Lower Tunbridge Wells Sand is quarried on the north-east of War's Farm, near the brook. It is here a very soft sand-rock, breaking easily into sand of a pale yellow colour with dark bands, and is much acted upon by the weather." †

"At Maset's Place the top beds are soft sand-rock, 8 or 10 feet thick, with mottled clay above, which is made into bricks." †

"At Lindfield Farm the sand contains a flaggy, black, crystalline, calcareous sandstone, occurring in all positions, sometimes nearly vertical. It is dug for road-stone." †

GRINSTEAD CLAY.—In the neighbourhood of the town whence this bed has its name the characters of the clay very closely resemble those of the Wadhurst Clay of this and other districts. It

* From MR. BRISTOW's note book. † From MR. BISHOPP's note book.

is composed of shale and clay, with sometimes a little red clay at the top. The highest beds of the underlying sand are often rocky, as already noticed. There is therefore no positive characters by which to distinguish the two clays, and their relations can only be determined by mapping the ground.

There are some points, however, which are useful in identifying this stratum. Although it is underlain by a rock-bed, which is frequently conglomerate at the top, just like the Ashdown Sand, yet I believe there are no "mine-pits" in the clay above; nor does the "shelly bed" occur which is so characteristic of the base of the Wadhurst Clay. The Grinstead is much thinner than the Wadhurst Clay; its usual thickness at East Grinstead appears to be only 40 or 50 feet, but in a well at the Brewery in that place I was told there was 70 feet of blue shale passed through, containing beds of "limestone;" these were probably calc-grit, which occurs in this bed as in the Wadhurst Clay. This unusual thickness, supposing the information to be reliable, may perhaps be caused by a local flexure of the bed causing them to be cut obliquely by the well; there seems no reason to suppose that the thickness of the clay is really so great as this.

The separate mapping of this division has only been carried for some three miles east of East Grinstead, but it has been observed in places further east, as "in Penshurst Park and in the road-cutting that runs along the west side of it. Here I measured 17 feet of clay, and I saw below it a bed of white rock-sand; while the Wadhurst Clay is not far beneath." *

The following are some notes on the Grinstead Clay in the district south-west of East Grinstead, from Mr. Drew's MS.:—

"It is shown in the railway-cutting west of the Warren and just south of the 31st mile-post, where the purple clay is covered by sand. At the brickyard, three-quarters of a mile from Paddockhurst, on the road to Turner's Hill, where there is red and purple clay at the top of this division. A few hundred yards south of Lower Farm there is a considerable thickness of red clay with stiff clay below; and in some pits, a quarter of a mile and more to the east, some thickness of clay is again shown. In the gully running north towards Rowfant there is shale, and at the rabbit-warren south-west of Miswell Farm, and in some pits a third of a mile to the north-east, there is red clay."

"At the north end of Balcombe Tunnel there is a very fine section of Grinstead Clay:—

		Ft.	In.
Upper Tunbridge Wells Sand.	Stony sand - - - -	7	0
	Sandstone, with partings of white loam	5	0
Grinstead Clay	Blueish, rather loamy clay - -	1	6
	White and yellow clay - - -	3	0
	Purple clay - - - -	8	0
	Purple, rather shaly clay, with a little whitish clay and white sandy shale, succeeded by blue shale.		

* Drew, *Quart. Journ. Geol. Soc.*, vol. xvii. p. 281.

"In another part of this section, on the west side of the cutting, 10 feet or more of dark blue shale is seen; the purple clay passes into this.

"South-west of the *C* of *Cinder Banks* little openings by the side of the railway showed

Sand and loamy stuff.
Purple clay, with shaly stuff in it (Grinstead Clay)."

MR. HAY observed grit in the clay in stream-sections near Dencombe and Brantridge, in the streams running from Balcombe Down, and in the road at Pilsty. There is a large quarry for grit south-west of Bowder's Farm where a small *Paludina* and *Cyrena media* occur. Grit also occurs in the stream east of Holt Farm.

The following note is by MR. BRISTOW:—"In some fields which were being deeply drained in November 1861, east of the brook by Cockease Mill and W. of the road to Trimming's Farm, the Grinstead Clay was red in the upper part, and about the middle contained beds of white gritty sand and sandstone. Beneath this the clay was mostly green, and close to the brook there was a bed or thinnish layers of irregular, dark, chocolate coloured sandstone with casts of *Paludina*. The colour seemed to be due to animal or vegetable matter. The beds were lying flat, and the same dark sandstone was observed to crop out to the surface in the road to Trimming's Farm, where the small piece of the wood abuts on the east side of the lane, just south of the stream."

In a cutting on the Lindfield and Uckfield railway there is the following section, showing the upper junction of the Grinstead Clay repeated by a fault. The clay is red at the top in some places, and above that there are massive beds of sandstone (Upper Tunbridge Wells Sand), with a layer of loam. This cutting is between Copyhold and Kenward's Farms.

Fig. 15. *Railway cutting, north-west of Lindfield; showing Junction of Upper Tunbridge Wells Sand and Grinstead Clay, with Fault.*

In cuttings along the same railway, east and west of Buckham Hill, near Uckfield, red and blue clay is seen below sandstone. About 12 or 14 feet up in the sandstone, on the west side of the hill, there is a bed of clay, thinning out to the west, but apparently thickening *into* the hill. The hill itself seems to be on a small synclinal.

The Grinstead Clay of the Uckfield district is as a whole less like the Wadhurst clay than that at East Grinstead. It is apparently not constant, the two sandy divisions coming together in places as shown on the map. It is often more mottled and less shaly than the clay at East Grinstead.

The following note is by MR. BRISTOW. The clay referred to is probably Grinstead:—

"At a house called Cobb's Nest, at the top of the *k* in *Newick Green*, a well was sunk to a depth of 64 feet. The lower three feet was rock, with about 20 feet of tea-green and purple variegated shale above it; the shale was harder and more gritty in the lower part. The water came in on the north side, on the top of the sand rock, which, also, probably throws out the spring to the north, by the notch in the wood, the water from which was used before the well was made."

The following is an account of the strata passed through in the well of Hayward's Heath Lunatic Asylum:—

		Ft.	In.
Top Upper T. Wells Sand, 84 feet.	Surface soil	0	9
	White loamy clay	5	3
	Fine grained yellow sand	5	6
	Very fine sand	1	6
	White clay	10	0
	Fine white sand.	4	9
	Grey and white sand, finely laminated	10	3
	Pipe clay, with vegetable impressions	1	0
	Grey sand, " " "	4	0
	Sand and conglomerate	2	0
	Compact sand	15	0
	White sandstone, with carbonaceous specks	1	0
	Fine sand with vegetable impressions	9	0
	Iron pyrites	1	0
	Fine loose whitish sand	11	0
	" " " " , rather clayey	2	0
Cuckfield Clay, 14 feet.	Slate coloured clay	2	0
	Sand	1	0
	Blueish clay	11	0
Bottom Upper T. Wells Sand, 69 feet.	Fine grained sand [? rock bed]	16	0
	Blue clay	1	0
	Fine grained sand	16	0
	Sand, rather clayey	36	0
Grinstead Clay, 43 feet.	Greenish clay	5	0
	Red and green clay	2	0
	Red clay	2	0
	Clay	34	0
		210	0

As this section was prepared from specimens only, which had been preserved for some time in boxes, it is likely that the characters here given to the beds are not always exactly those presented in natural section. The loose sands may be rock-beds which have crumbled into sands, as such beds often do when freshly dug. The thicknesses of the smaller beds may also be slightly incorrect. This is very likely to be the case with the bed of *iron pyrites*, a little above the Cuckfield Clay. This mineral is rare in the Wealden rocks, and we are justified in doubting if the bed be really as thick as this section states. It may be, however, that the peroxide of iron, which is so abundantly diffused through the rocks which we now find near the surface, may occur as sulphide at greater depths. Near Ferques, in the Boulonnais, sulphide of iron occurs and is worked in the Wealden beds (see p. 346); and it also occurs in Weald Clay, in the railway cutting near Pevensey (see p. 97).

UPPER TUNBRIDGE WELLS SAND.—This greatly resembles the beds which occur at the same horizon further east. At the top the beds are often rocky; below, they consist of interbeddings of sand, sandstone, and loam.

In a very much disturbed district south-west of Groombridge there are some patches of clay believed to be Weald Clay. The following succession is seen in the railway cutting west of Ham Bridge:—

		Ft.	In.
Weald Clay?	Sandstone	4	0
	Clay and Shale (At the top there is red and green clay, brown shale below.)	25 to 30	0
Upper T. Wells Sand, 60 ft. 6 in.	Sandstone	6	0
	Green clay and shale	3	0
	Sandstone	20	0
	Shale	2	6
	Sandstone	6	0
	Clay and shale	3	0
	Shaly sand	2	0
	Hard sandstone	6	0
	Clayey sand	2	0
	Sandstone	10	0

In a quarry half-a-mile west of Chiddingstone Church there is some decomposed calcareous sandstone, one layer of which contains a great number of fossils; *Unio* (large species), *Cyrena*, *Paludina*, *Cypridea*, and Fish. The calcareous bed has been about two feet thick, but is undecomposed for only one or two inches in an irregular line; the rest is now a sandstone which sometimes exhibits concentric wavy lines of infiltration or decomposition. At the top of this quarry there is some clay and sand with pieces of sandstone; this is a wash, but the Weald Clay would not be far above.

The rock-sand at the top "forms a fine line of rocks at Redleaf, Penshurst, and is again exposed in Chiddingstone Park. West of this for a few miles the outcrop of this part of the series is interrupted by some faults. At Stamford End, Edenbridge, rock-sand is again seen at the horizon that I am speaking of: but this is about its last point; for further west the top of the Wells Sand is thin-bedded sandstone, with some loam interstratified; and of this same description is all the upper half of this division."*

The following notes on the country around Worth, at the south-western corner of Sheet 8, are from MR. DREW'S MS.:—

"Nearly half a mile south of Fay Gate Station there is a quarry in iron-sandstone; half a mile east of Home Bush there is some rather ferruginous sandstone, and two layers of clay-ironstone enclosed in peroxide of iron; and about the same distance S.S.E. of Buckswood Farm a quarry shows sand, sandstone, and two layers of iron-sandstone. These ferruginous beds must be nearly at the top of the division, and the new road-cutting a little north

* DREW, *Quart. Journ. Geol. Soc.*, vol. xvii. p. 281.

of Furnace Farm gives a section of sand and loam also just at the top.

"About Three Bridges and between there and Copthorn Brow there is no good section in the upper part, which here consists of loamy sand with a little sandstone. Lower down, however, there is a sandstone quarry, by the side of the railway south-east from Furnace Farm; the cutting on the south shows loose sandy earth with a little stone, just above the Grinstead Clay; the brickyard by Old House, to the east, shows many feet of white and red loamy clay, which must not be mistaken for the Grinstead Clay, as it is well above that bed; and a quarter of a mile further east is a small pit in sandstone.

"The best sections of these sands are in the railway-cuttings between Three Bridges and Grange Road Stations. In that north of Worth the beds vary very much, some thinning away in a few yards: they consist of sandstone and loam (partly hard and shaly), with thin lenticular layers of lignite.

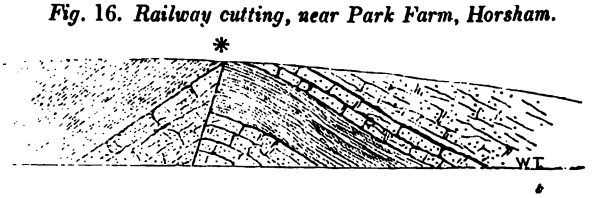
"The cutting at the south-western corner of Crawley Down gives the following section, and here too some of the sandstone beds are lenticular:—

	Ft.
Loamy sand	7
White sandstone	4
Loam and sandstone	6
Sandstone	3
Loam	6
Buff sandstone	2
Loam	10
	38

"Red loamy clay, like that at Old House, is dug at the brickyard by the side of the footpath from Rowfant to Turner's Hill, and there are some small sections of loamy sand and rubbly sandstone on the southern side of Copthorn Common."

The cutting south-west of Park Farm, north of Horsham, exposes a faulted junction of Weald Clay and Tunbridge Wells Sand; the fault throws to the north. Slickensides were very plain here; they were inclined 60° from the vertical towards the west. The beds therefore seem to have moved sideways, towards the west, but inclining down to the north. The Weald Clay contained some small nodules of ironstone. The upper part of the fault at * was obscured by tumbled stuff, only the lower part of the cutting was clearly seen just here.

Fig. 16. *Railway cutting, near Park Farm, Horsham.*



CHAPTER VII.—HASTINGS BEDS *continued.*

4. Cuckfield District.

It will be convenient to treat as a whole the small district around Cuckfield, taking as a boundary on the north the long inlier of Weald Clay, on the east the London and Brighton Railway.

This district is of very great interest, for from it most of Dr. Mantell's saurian remains were obtained. The exact positions of the quarries cannot always be determined, as Dr. Mantell generally spoke of the district as "Tilgate Forest," without specifying the particular places.

Around Cuckfield the beds are nearly horizontal, but they dip away to the north and south as we go in either direction. Cuckfield is partly built on clay, which from its being certainly the highest bed of the district, is considered to be Weald Clay. There are four well marked outliers of this at or near to Cuckfield, and some others on the west and south. The Weald Clay here is generally a stiff clay, or a shale in freshly cut sections. Sometimes it is slightly coloured, and in the road south-east of Cuckfield there is a good deal of bright red and mottled clay.

The *Cuckfield Clay*, which has only been mapped in the district now under consideration, is often a somewhat sandy and mottled clay, but is sometimes stiff and shaly. This clay divides the upper Tunbridge Wells Sand into two parts.

The *Grinstead Clay* does not much differ from that already described in other districts. It was well seen some time since in the railway cutting just north of Hayward's Heath Tunnel.

The most important section in the district is the quarry near the Windmill, at Whiteman's Green. It was here that Mrs. Mantell in the spring of 1822, first noticed the tooth of an Iguanodon, and from the same place a very large number of Dr. Mantell's specimens came.*

A large part of the field in which the quarry stands has been worked over, and the section will necessarily vary somewhat as different parts are exposed. In March 1872 I noted the following:—

	Ft. In.
1. Shale (*Weald Clay*) - - - - -	
2. Thin inconstant bed of rather pinkish rock-sand. As this bed is sometimes absent, the shale rests rather unevenly upon the bed No. 3 - - -	0 to 3
3. Line of quartz pebbles, sometimes 1 inch or more thick, then forming a conglomerate, and containing fragments of bone and teeth - - -	0 to 1

* William Smith had, in or soon after 1809, obtained many bones from this quarry, which in 1815 were deposited in the British Museum (see p. 11).

	Ft.	In.
4. Ripple-marked sandstone, with thin lines and concretionary masses of Tilgate stone in the lower part	8	0
5. Conglomerate, chiefly of quartz pebbles - -	0	6
6. Sandstone and Tilgate stone, the latter in larger masses than above - - - - about	8	0 seen.

The conglomerates contain small rounded fragments of a substance greatly resembling Chalk, and as such it was originally described by DR. MANTELL, who speaks of the conglomerate "as a diluvial aggregate."* This chalky substance, which is not uncommon in Wealden conglomerates (see p. 84), is probably derived from the Portland Beds.

As already stated, it is generally difficult to recognise the localities of the quarries described by DR. MANTELL, but it seems very probable that the quarry, of which a sketch is given in the frontispiece to the "Geology of the South-east of England, 1833," is that just quoted.

The section described by DR. MANTELL is as follows† :—

1. Loam, from 5 to 7 feet.
2. Sand, and soft friable sandstone, of various shales of yellow, green, grey, and ferruginous, 8 feet.
3. A bed of fine, compact, blueish-grey, calciferous sandstone (*Tilgate grit*), embedded in sand; varying in thickness, from 1 to 9 feet; the lower portion a conglomerate.
4. Blue clay or marl. The base of the quarry; thickness unknown; wells are sunk in it to the depth of 17 feet.

The calciferous grit (Tilgate stone), "differs in a few particulars from that of 'White Rock' [Hastings]: it is less homogeneous; is generally of a darker shade of blueish or greenish grey; occurs in masses that are more tabular, and the lower portions form a very compact conglomerate, enveloping large rolled pebbles of variously-coloured quartz, jaspar, and small ones of pure white quartz, and flinty slate. It also contains organic remains, in far greater quantities than the stones at Hastings; bones, more or less rolled; teeth, &c. are to be seen in almost every fragment; and the carbonised remains of vegetables are equally abundant. It is exceedingly compact, and offers great resistance to the hammer; it scintillates with steel, effervesces strongly with acids, and varies considerably in purity: it contains about 25 per cent. of carbonate of lime. Lenticular and tabular crystals of carbonate of lime frequently occur in the hollows of the stone, and in the medullary cavities of the bones, fissures of the lignite, &c. This bed is separated into irregular layers, of from 3 to 12 inches in thickness, by blue marl or clay; and the compact masses, when removed by the quarrymen, and cleared of the surrounding sand or clay, present the same concretional or lenticular forms as those on the shore, at Hastings, that have been washed out by the breakers; the same kind of mammillary projections on the surface

* Fossils of the South Downs, 1822, p. 39. Large pebbles sometimes occur in this conglomerate. See footnote on p. 187.

† Geology of the South-east of England, 8vo., 1833, p. 209. This part of the book is a reprint from the "Illustrations of the Geology of Sussex . . . . . with Descriptions of the Fossils of Tilgate Forest," 4to., 1827, p. 38.

of the stone are also observable.* The *conglomerate* is one of the most remarkable features of these strata; it appears to be composed of the grosser materials of the bed, such as pebbles, rolled masses of sandstone, bones, &c., and even the finer parts of it are made up of grains of sand, and comminuted bones, teeth, &c.; the whole has evidently been the sediment of a current of water, subsequently consolidated by a subcrystalline, calcareous cement: almost all the bones found in it are more or less rolled, the greater part being mere fragments, rounded by attrition. This conglomerate, varying in texture and composition, occurs in greater or less force, in almost every quarry, in this part of the Tilgate Strata. In some instances layers of a coarse friable grit, with calcareous concretions, occupy the upper part of the beds, as is the case in many places in the town of Cuckfield, where it rises so near the surface as to be exposed in digging the foundations of houses, &c."

It will be noticed that in the foregoing description DR. MANTELL places the conglomerate at the *bottom* of the bed or beds of Tilgate stone, whereas in the section which I have given of Whiteman's Green quarry, it is placed at the top. This without doubt is the position of the conglomerate now exposed (1872) in that quarry. Either there is another band of conglomerate beneath the Tilgate stone not now visible (or possibly now absent), or DR. MANTELL has erroneously described the beds. I should not venture on suggesting this alternative if DR. MANTELL had not himself, in an earlier work, given what is probably the correct order, as follows† :—

	Ft.	In.
1. Conglomerate - - - - - -		
2. Sand and sandstone - - - - - -	7	0
3. Compact blueish-grey limestone [Tilgate stone]. The *upper* layers are a compact conglomerate; but the lower are perfectly homogeneous - - -	9	0
4. Blue tenaceous clay.		

It is evident that the beds here numbered 1 to 4, respectively correspond to the Nos. 3 to 6 of the section of Whiteman's Green Quarry, given on p. 91.

The following notes have been supplied me by MR. BRISTOW, who mapped the country around Cuckfield. The sections follow in order going south-west from Cuckfield as far as Bishopstone. Hill Farm and Collard Farm are about 2½ miles due west of Cuckfield; Board Hill is 2 miles north-east of that town.

Cuckfield Place.—The well at the New Lodge, at the entrance to the Park, by the avenue, was sunk 25 feet, all through sand, without any water being got.

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* "In many of the quarries near Tilgate Forest the concretional formation of the stone is clearly shown; although, from its being encrusted with sand, it appears like blocks of the friable sandstone; and as it maintains the same sedimentary line as the sand in which it is embedded, the layers appear like tabular strata, till examined with attention."

† Fossils of the South Downs, p. 38; and *Trans. Geol. Soc.*, ser. 2, vol. i. p. 423.

The stone for the lodge was obtained from the Windmill Quarry, and the sand was brought from Bentley Farm (two miles N.N.E. of Cuckfield) which was said to furnish the best sharp sand for making mortar in this neighbourhood.

The road running in a westerly direction from between two ponds, was cut through about 3 feet of green clays, with thin slaty lines of sandstone, containing casts of small *Cyrena*, *Cypridea*, and *plant stems*.

Ansty Cross.—Thin beds of sandstone are seen in the road, coated with a thin crust of ferruginous sandstone, or siliceous ironstone. The direction of the joints is about 5° W. of S, and 20° N. of E.

Little Ease.—In a road-cutting (not marked on the map) N. of the farm-buildings, a thick bed of buff-coloured sand-rock was seen with ferruginous stains, and the surfaces of the joints stained brown by oxide of iron. The uppermost part of the bed also consists of a thin line of hard ferrugrious grit. Above that three or four feet of pale cream-coloured or pale-grey sandy marl succeed, which are in turn overlain by laminated sands. The section closely resembles that exposed in the openings on Hayward's Heath where clay is dug for brick-making. The dip of the sand-rock is 35° S. of W. at an angle of 9°.

Bishopstone.—There is a good section displayed in the road, which has been cut through the hard thick bed of rock-sand belonging to the Upper Tunbridge Wells Sand. This is overlain by pale marly sands, and on the south side of the fault by yellow shaly sands, which seem to rest on the rock-sand unconformably. The fault appears to cross the road at the N. end of the southernmost farm-buildings, and by it the sand-rock is cut off and brought in contact with the uppermost sandy beds. The effect of the disturbance has been to produce an upthrow on the south side of the fault, and to repeat the beds, which are again exposed further up the lane in a northerly direction. The dip of the beds is 8° on the south side of the fault, and 9° to the north of it; in both cases in a direction a few degrees west of south.

Pickwell Farm.—In the road N.W. of the brook, about four chains above it, thin bands of sandstone were seen in the bank, dipping to the south-east at an angle of about 50°, the high angle of inclination being caused by a fault.

Up the brook in a north-easterly direction, pale, thin-bedded sandstone was dug, overlain by a pale clay or marl, and with a dip of about 2° in a direction 20° W. of S.

Brandsnape.—In the lane, from Brandsnape to Brock, at 130 yards, the section of the beds is very well shown. They consist here of soft sandstone and sands of a pale yellow or nankeen colour, with (iron-stained) rusty lines, stains, and patches. There is a three-foot bed of pale marly sandstone overlying a soft pale or whitish rock, which is succeeded by grey, laminated, soft, sandy beds. The dip is 10° in the direction of the lane. The sandstones seem to have slipped along the escarpment in a southerly direction, resulting in a series of very trifling dislocations, each a foot or so in amount, sometimes slightly squeezing and crumpling the upper softer grey beds. At Brandsnape the sand-rock was observed in the road-cutting. The farmer described it as being more than a yard thick in some places, with marl below. Probably the large pits by the farm-buildings (now filled with water) situated on both sides of the lane, were originally quarried for the stone lying next to the surface, and were afterwards used for getting out the marl.

Hill Farm.—Bricks are here made of green and red marls. The total thickness is 40 feet, viz., 10 or 12 feet to a black rock, which is about 2 feet thick. At 40 feet there are small irregular-shaped irony nodules, and small pieces of ferruginous sandstone of a dark colour and with a burnt appearance (sometimes nearly black) inside, but white outside.

Collard Farm.—Direction of joints 40° W. of N. and 30° N. of E. Dip 30° W. of N. 5°. The bottom of the quarry consists of hard sand-rock, well and clean-jointed. The upper bed is 4 feet, the lower 6 feet thick, with a ferruginous band an inch thick on the top, where the upper bed of sandstone, on exposure to the weather, splits off.

There are from three to four feet or so of softer shaly sandstone above, underlying clay which is white, marly, and sandy for the lower six inches, but becomes dark and laminated through the rest of the section, for about 8 or 10 feet. The clay weathers of a rusty-brown colour. At the cross-roads it turns up quite black and not at all laminated.

The sandstone furnishes good blocks for building; about a foot thick on an average, and of various dimensions, 15 in. × 10 in. to 18 in. × 10 in.

The larger beds, of a light fawn-colour, come out of a like thickness to the above, but in larger blocks, about 3 ft. 6 in. by 5 feet.

There is a curious circumstance observable in this quarry, that from the bottom of the clay the sandstone beds seem to have contracted, the result being a series of vertical fissures along the direction of the joints, like those traversing the Portland Stone of the Isle of Portland, only on a much smaller scale and closer together. These vertical cracks or fissures do not, apparently, extend into the soft and shaly upper sandstone. Fish remains were noticed on the hard sandstone.

Board Hill.—Sand-rock was seen in a quarry south of the letter *B* on the map; also in the lane to Wickham, where it dips about 5° in a direction a little east of north. The dip is 10° in the lane across the rivulet. There is a good section of the sands and sandstone in the railway cutting east of Board Hill. Rock is also seen in the farmyards at Sudgate, and clay in the dotted road, in a south-westerly direction, to the cross-roads.

H. W. Bristow.

CHAPTER VIII.—WEALD CLAY.

This formation, as its name implies, is nearly all composed of clay. That is to say, of clay when the beds are seen in their ordinary state near the surface, but when freshly exposed in deep sections they are generally shales. In colour the shale is generally brown or blue: the clay which it forms is often of the same colour and as often yellow. Occasionally there are red or mottled clays, but these generally occur in association with the subordinate sand beds.

Besides the shale, there are found beds of limestone, sand or sandstone, and clay-ironstone in nodules. The beds of limestone and sandstone can sometimes be traced continuously for considerable distances; but at other times, and this is the general rule, the beds can only be observed at intervals. This may be due to the thinning out of the bed along its strike, or it may be that the bed is frequently present but has escaped observation. In many cases the latter explanation is probably the true one; for these thin, subordinate beds, with one exception, have not been carefully traced in detail, and are therefore not shown on the Geological Survey Maps. The limestone is composed almost entirely of *Paludina*.

In thickness, the Weald Clay varies much. It appears to be thickest in the meridian of Leith Hill, where crossed by the horizontal section, Sheet 75. Here it is probably 900 or 1,000 feet.* From the meridian of Leith Hill, which is about the westerly extremity of the Hastings Beds' area, the Clay thins away eastwards. MR. DREW estimated the thickness of the Weald Clay at 600 feet about Tunbridge and Maidstone, on the following grounds. "A boring at Brenchley's Brewery, at the bottom of Gabriel's Hill, Maidstone, which began about at the top of the Weald Clay, went through 500 ft. of clay (passing a water-bearing sand at 100 ft.), and did not reach the bottom. Another boring, at Allnutt's Paper-mill, Tovil, near Maidstone, began at the top of the Weald Clay, passed a water-bearing sand at 115 ft., and went through, on the whole, 600 ft. of clay down to a hard rock, which they did not pierce, and which very likely was the top of

* In the early impressions of this section a far less thickness than this was assigned to the Weald Clay, only 650 feet. In the total absence of any positive evidence I did not feel justified in allowing a greater thickness than this, which only slightly exceeds the amount that is *proved* at Maidstone. In the cuttings of the Horsham and Dorking Railway, however, there is a tolerably uniform dip to the north; if we take 1° as the average (and it is probably more), we require a thickness of clay *at least* as great as that stated in the text. The alteration is important, for in the first edition of this section the central line of upheaval, or that along which the lowest beds attain their maximum height, is drawn under Leith Hill; whereas by allowing a greater thickness of Weald Clay, the Hastings Beds are carried to a lower level below Leith Hill, and the central line of elevation is shown to lie near Horsham, where we should expect it to be. The *top* of the Weald Clay seems to attain its maximum height at Leith Hill, but this is owing to its great thickness here. This carries the central line of Watershed to Leith Hill, which elsewhere generally coincides with the anticlinal line (see the Map appended to this Memoir, Plate II).

the Hastings Sand. Again, the top of the Weald Clay at River Hill, on the Greensand escarpment, is 500 ft. above the sea-level; at Leigh (which bears from River Hill in a direction at right angles to the strike of the beds) the base of it is 80 ft. above the sea-level. Therefore, if the beds were flat between those two places, there would be a thickness of 420 ft.; but it is very likely that there is a general dip to the north (in one or two places I have seen the beds dipping in that direction); if it were only half or three-quarters of a degree, the thickness would be 600 ft. I am indebted to Mr. Bensted, of Maidstone, for the information about the borings." *

We have at present no means of estimating the thickness of the clay further east, but it probably thins regularly in that direction, and may not be more than 350 feet thick near Hythe.

Along the south side of the Weald the thinning out seems to take place more quickly, judging from the rapidly narrowing outcrop of the clay. On the opposite side of the English Channel, in the Lower Boulonnais, the Weald Clay has probably completely disappeared.

Red Clay is very often found, generally in association with the sand beds. It occurs very frequently along the south-eastern area of the Weald Clay, in Sheet 5; and I believe it has been found at the Royal Sovereign Shoal, which lies due east of Beachy Head and 6½ miles south of Martello Tower No. 49.†

The Weald Clay has in former times been very much dug as "marl," and its ironstone has been largely smelted, particularly in the western part of its area. Calcareous Grit occurs in places, often as lenticular masses in the clay; this and the limestone beds were formerly much dug for roads, and still are to some extent; they have also been used for building. Iron Pyrites occurs in balls of 3 or 4 inches in diameter in the railway cutting west of Pevensey.

Extremely few junction-sections are seen, either with the Tunbridge Wells Sand below or with the Atherfield Clay above. We will here note the general character of the division near its junctions, afterwards giving some notes on the courses of the subordinate beds.

At the north-eastern part of the Weald, in Sheet 4, the actual junction is often fairly distinct; the topmost bed of the Tunbridge Wells Sand being there rocky (see p. 76); but at the lower part of the clay there is some loam or loamy clay, which makes the boundary somewhat indistinct where the rock-bed is not seen. There is also, just here, some "crowstony" gravel, which still further tends to obscure the boundary.

From near the western end of Sheet 4, westwards, the southern boundary of the Weald Clay appears to be a fault, and here the lowest beds are not known. Still further to the west the junction

* *Quart. Journ. Geol. Soc.*, vol. xvii. p. 273.

† Report of Commissioners on the subject of Harbour of Refuge (1845), p. 214. "On the Royal Sovereign Shoal,.....the lead brought up red clay of as bright a colour as red lead."

is sharply indicated, shale and clay resting directly on the rock-bed of the Tunbridge Wells Sand; as in many places in the immediate neighbourhood of Tunbridge Wells. Hereabouts, however, there is a bed of loam and sand some 30 feet or so up in the clay. It was probably this bed that occurred in the railway cutting near Ham Bridge (see p. 89). The rock bed continues for some few miles west of the Wells, and here the boundary is still fairly defined, taking the thin sandy bed in with the clay. West of Lingfield the boundary is doubtful for a few miles, within narrow limits; much of the lower part of the clay being loamy in character. The boundary is again more definite in the eastern part of Sheet 8, west of Three Bridges Station, but is less so near Horsham.*

At Wivelsfield the exact boundary of the Weald Clay is doubtful. Here there is a bed of sandstone, on which Wivelsfield is built, which thins out to nothing on the west. It is last seen in the road north of St. John's Common. On the east, however, it thickens and joins on to the great mass of the Tunbridge Wells Sand. Below this and to the north of it is a bed of clay which, on the west, joins the great mass of the Weald Clay, but appears to thin out to the east; on the north-west of Chaily Common it ends abruptly, and what becomes of it further east is not certainly known. Possibly one of the beds of clay, separately coloured, may be the continuation of this. This wedge-shaped mass of sand, which I mapped with care at Wivelsfield, may, perhaps, be only an example of what occurs in other places where we are less able to trace the changes.

The lower boundary of the Weald Clay on the south side of the Weald is, as a whole, much less definite than on the north.

Of the upper boundary of the Weald Clay there is even less to say. It is generally indicated on the map by a broken line denoting that its position is doubtful. This is due to the fact that two clays come together which can only be separated in actual section. The upper boundary of the Atherfield Clay can, however, generally be drawn with tolerable correctness; and, its thickness being known, the lower boundary can be inferred.

At Hythe there is, near the top of the Weald Clay, an intermixture of marine and freshwater shells.

"Bands of *Ostrea distorta* associated with *Cyrena* have been found by Mr. Mackeson about 30 feet below the top of the Weald Clay behind the School of Musketry at Hythe. As in other areas there is here a distinct boundary between the Weald Clay and the Atherfield Clay that rests on it, for I am told that whenever a section is exposed, either by an unusually low tide, or by some artificial opening, the exact junction of the marine and freshwater formations can be made out. 'Associated with the *Ostrea distorta* and *Cyrenæ* are other fossils characteristic of the Wealden age, viz., *Cypris* [*Cypridea*] *valdensis*, *C. tuberculata*, *C. spinigera*, *C. granulosa*, *Paludina fluviorum*, and spines of fishes; and a little west of the town, 100 yards above the turnpike old road, good character-

* Mr. Drew, *Quart. Journ. Geol. Soc.*, vol. xvii. p. 280.

istic specimens of the argillaceous ironstone nodules crowded with the small *Entomostraca* above mentioned may be obtained.' "*

The top beds were seen in the railway cuttings at Haslemere and Witley (see p. 114).

As illustrations of the nature of the Weald Clay in large and freshly exposed sections we may take the following examples from railway-cuttings, excavated during the last ten years.

Sevenoaks and Tunbridge Railway (Sheet 6).†—The cutting at the *M* of *Mountain's Farm* gave a good section of Weald Clay, dipping 35° W. of N. at an angle of 5° :—

	Ft.	In.
Clay and shale - - - -	20	0
Shelly limestone - - -	0	0½
Shale and sandy clay (? calcareous) - -	8	0
Shelly limestone with "beef" at bottom -	0	1
Shale - - - - - -	5	0
Shelly limestone with *Cyrena* - -	1 in. to 0	1½
Shale (*Cypridea* and *Cyrena*) - - -	0	5
Shelly limestone with "beef" at top - -	0	0¾
Shale - - - - - -	6	0

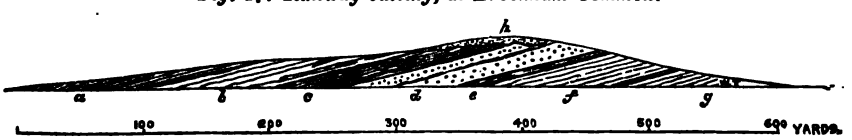
Crystals of selenite were very common here.

The cuttings near the entrance to the tunnel showed some sections of shale near the top of the clay, and in one a layer of Paludina Marble was found 22 inches thick, sometimes in one bed, sometimes in two. Several of the shafts further north reached down to the Weald Clay.

Horsham and Dorking Railway.—The cuttings of this line present but few points of interest, some beds of sand were cut which will be presently noted. A fault near Horsham has already been figured (p. 90).

Fig. 17 shows a cutting at Brockham Common. It is doubtful to which of the beds hereafter described, if to any, the sand here belongs. It is 12 feet thick, and makes a slight feature east and west of the railway, as shown in the sketch. The depth of the cutting is necessarily much exaggerated, and consequently the dip, thickness, and slope also; the true dip is 3° or 4° a little west of north.

Fig. 17. *Railway cutting, at Brockham Common.*



h Sandy wash.

a Brown and reddish clay and shale.
b Blue clay and shale.
c Whitish clay.
d Sand with a thin bed of white clay.
e Blue and brown clay.
f Red clay.
g Brown clay.

* Mr. Drew, *Mem. Geol. Survey*, Sheet 4, p. 6. The quotation is from Mr. Etheridge's Note Book. These bands of *Ostrea* intermixed with freshwater shells appear to represent the Punfield Formation (*see* p. 110).

† Mr. C. Evans has described some sections afforded by this railway. See *Geologist*, vol. vii. p. 34, and *Proc. Geol. Assoc.*, vol. i. (No. 11), p. 390.

*Horsham and Guildford Railway.**—Sand with red clay occurs in the cutting near Upfold's Farm.

The cutting east of Snoxall Farm shows clay and shale with *Cypridea* and nodules of ironstone. The dip is northerly 1° or 2° at the south end of the cutting, but increases to 5° at the north end.

In the cutting east of Newhouse Farm the following section was seen:—

	Ft.	In.
Soil and Gravel - - - - -	1	6
Clay - - - - - -	1	6
Sand and thinly bedded Sandstone -	7	0
Red Clay (not constant) - -	0	1
Clay, mottled in the middle part -	16	0
Hard Sandstone, weathering black -	0	8
Sand, with a clayey parting - -	1	0

The dip is north 2°.

At Lodge Farm the cutting showed clay with beds of sand and some decomposed calcareous sandstone, also a one-inch layer of lignite.

A little further south there is a cutting nearly all in sand, giving a thickness of about 20 feet. Clay comes out from beneath the sand at the southern end of the cutting, but the top of the sand is not seen. The dip is 1° to 2° to the north.

At the north end of the Tunnel west of Linacre Farm a good section of clay and shale was seen, much of it mottled with green and red. There is a thin bed of sand which is sometimes a hard calcareous sandstone, and some ironstone. The dip throughout the tunnel is to the north. There is red and mottled clay at the south end of the Tunnel.

North-east of Great House Farm there is hard calcareous sandstone. It occurs in large concretionary nodules and decomposes into a soft sand.

At Rudgwick station large quantities of shale were dug out. The section exposed no beds of sandstone. The shale contained *Cypridea* and *Unio*.

The foregoing notes refer to Sheet 8, the following to Sheet 9.

A cutting near Park Farm showed brown and blue shale, with beds of calcareous sandstone containing fish and plant remains, and a thin bed of shelly limestone with *Paludina* and *Lepidotus*. The shale contains *Cypridea, Paludina,* and fish remains. A small fault was seen in the shale throwing down to the north.

South of Park Street there is a thin layer of fossiliferous blue limestone.

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* These sections follow from north to south, that is, from above downwards.

The following detailed sections from MSS. in the Library of the Geological Society, will show the character of the beds as noted by well sinkers*:—

Well at Warnham, near Horsham.

(Sunk for 44 feet, the rest bored.)

	Ft.	In.
Bluish clay	7	0
Red sandstone	0	9
Bluish clay	20	0
Red sandstone	0	8
Blue clay	14	7
Hardened blue clay	2	6
Blue clay	31	6
Water-bearing bed	1	0
Blue clay	35	0
Hard sandy clay	3	0
Blue clay, with fragments of other formations [?]	27	0
Red clay, with fragments of red sandstone [?]	8	0
	152	0

Section of a Well at Mr. Gurney's, Redhill.

			Ft.
[Hythe Beds]	1.	Light sand	53
[? Atherfield Clay 55 ft.]	2.	Brown clay	1½
	3.	Green sand	5½
	4.	Brown clay	13
	5.	Stone	1
	6.	Greensand	25
	7.	Stone	2
	8.	Greensand	7
[? Weald Clay, 334 feet.]	9.	Blue marl	10
	10.	Stone	1
	11.	Blue marl	12
	12.	Stone	0½
	13.	Blue marl	9½
	14.	Stone	1
	15.	Blue marl	40
	16.	Stone	1
	17.	Blue marl	14
	18.	Stone	2
	19.	Blue marl	42
	20.	Stone	4
	21.	Blue marl	10
	22.	Red marl	2
	23.	Blue marl	54
	24.	Blue and White marl	100
	25.	Stone	7
	26.	Coloured clay	4
	27.	Brown clay	2
	28.	Black clay	2
	29.	Coloured clay	6
	30.	Sandstone	6
	31.	Red marl	4
		Total	442

* Mr. G. R. Burnell (*Journ. Soc. Arts*, vol. x. p. 160, 1862) refers to these well sections.

There are but few traces of Weald Clay within the Hastings Beds area. Some outliers near Tunbridge Wells have already been mentioned in describing that district. There are some patches of clay on the higher grounds at Cuckfield, which are believed to be Weald; as is also the long band of clay ranging east and west, along the low ground, on the north of Cuckfield. There is a good deal of red and mottled clay in this outlier; and MR. BRISTOW informs me that this is the general character of the lower part of the Weald Clay here, and to the south. At Biggs' Farm there is a quarry in this clay, at which grit and sandstone is dug; the beds are dipping high towards the south.*

We may now take in hand the subordinate beds of sand and limestone, describing them in ascending order. The largest number of these beds occur at the western end of the Hastings Beds; only one, the upper bed of marble with large Paludina can be traced all round the Weald with tolerable certainty.

The succession of these beds is as follows:—

No. 7. Sand.
„ 6. Limestone "Sussex marble" (*Large Paludina*).
„ 5. Sand and Sandstone with Calcareous Grit.
„ 4. Limestone (*Large Paludina*).
„ 3. Limestone (*Small Paludina*).
„ 2. Sand and Sandstone.
„ 1. Horsham Stone.

Of these, the lowest, or Horsham Stone, is the most important.†

Horsham Stone.—The horizon of this bed is about 120 feet above the base of the Weald Clay. It is a calcareous sandstone splitting well into slabs, which are used for building, paving, and roofing. Associated with it are beds of sand and sandstone not calcareous, and there is always some interbedded clay. The stone is often strongly ripple-marked.

The area coloured on the map as "Horsham Stone" is by no means all light land. It must be taken as indicating the district within which *stone* occurs at or close to the surface. Within the limits of the "Horsham Stone" there is a good deal of clay, and this makes the land, perhaps, more stiff than light. Some of the valleys will, no doubt, cut through the stone into the underlying clay. The following sections, taken in the neighbourhood of Itchingfield and Slinfold, will sufficiently indicate the character of these beds.

The railway cuttings north and north-east of Itchingfield are chiefly in clay and shale, but some thin beds of sandstone and calcareous sandstone occur, which are part of the Horsham stone The dip is westerly, at a low angle.

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* PROF. T. R. JONES on "Trails, Tracks, and Surface Markings," *Geologist*, vol. v. (1862), p. 135, figures and describes a slab of sandstone from this quarry.

† A great part of the following details is taken from MR. DREW'S Notes.

Quarry within the triangle formed by the three lines of railway (? Stammerham Quarry)* :—

			Ft.	In.
Clay			2	0
Stone (with clay), thinly bedded and decomposed			1	0
Shale			8	0
Hard stone	Calcareous sandstone	Ft. 1, In. 0	1	6
	Sandstone (for building)	0 6		
Shale			2	0
Stone	Calc-sandstone	Ft. 2, In. 6	4	6
	Sandstone (for building)	2 0		
Shale below, for at least			30	0

The dip is 3° W.S.W.

Another quarry, a little further west, showed three feet of calcareous stone with a little sand. Two thinner beds of stone above were inconstant.

Stone has formerly been a good deal dug about Grig's Farm. No quarries are now open, but the following section was obtained from one of the workmen:—

	Ft.	In.
Clay	4	0
Stone (used for roadstone)	0	2
Clay	6	0
Stone	4	0
Sand or Sandy Stone	—	

The second layer of stone changes sometimes into sand.

By the stream south-west of Grig's Farm is the following section:—

		Ft.	In.		Ft.	In.
Stone	Stone	1	4		4	0
	Thinly-bedded sand	0	3			
	Stone	0	4			
	Clay and Sand	0	4			
	Stone	0	9			
	Clay and sandstone	1	0			
Clay and shale					1	2
Stone (Ripple-marked)					0	3
Shale					1	6

The top beds of stone are much weathered, and only the 3-inch ripple-marked bed shows traces of limestone.

The following notes on the Horsham Stone, a few miles to the south of Horsham, are by MR. BRISTOW:—

"The Horsham Stone is seen a little to the northward of Coney Farm, 2½ miles N.E. of West Grinstead. The bed quarried there is about 5 ft. thick, but generally, in this particular district, the stone is not more than 2 feet in thickness. The stone was met with in the brow of a field north of Smallham Farm, by SIR PERCY BURRELL'S men, but it was too thin and poor to pay for working, and has only been quarried for the roads to the east.

* A description of Stammerham Quarry, by SIR CHAS. LYELL, was published by DR. MANTELL in *Geol. Trans.*, ser. 2, vol. ii. p. 131.

"Coney Farm quarry is situated about 10 chains north of the houses. The stone lies about 5 ft. beneath the surface of the ground, and is about 5 ft. thick, breaking into pieces about 5 in. in thickness, with a brownish exterior and a blue core, and somewhat like the stone at Whiteman's Green, near Cuckfield.

"A quarry was opened 200 yards north of the Farm; the upper part of which consisted of clay, overlying a sandstone which was got out in square pieces 12 in. × 8 in., and 3 in. or 4 in. thick. The dip of the beds was towards the Farm. The stone was a brown, hard grit or coarse sandstone, with a blue core inside when the blocks were broken."

The stone generally makes a feature on the surface by which the outcrop can often be traced where the stone is not actually worked. It thins away eastwards along its northern outcrop. As far as Fay Gate station it can be continuously traced, and has been drawn on the map (Sheet 8). A little further east, just south of Crawley, there is a feature made by this bed, on which, at Goff's Hill and Hog Hill, there is sand with a little calcareous grit.

No. 2. *Sand and Sandstone.*—This bed is first seen on the borders of Romney Marsh, at Hurst, where there are 8 feet or more of moderately coarse rock-sand. Proceeding westwards it is found at Bilsington, Horton Green, Orleston, and in a wood three-quarters of a mile west of Woodchurch Beacon; all these places are in Sheet 4. The course of this Sand is uncertain for many miles to the west, indeed it is not certainly known in Sheet 6. At Leigh, 2 miles west of Tunbridge, there is some sand north-east of the village, which may belong to this bed. Again, at the eastern part of Sheet 8, at Smallfield Place and west and north-east of it, there is sand.

Probably this bed dies out and is replaced further west, at or near the same horizon, by a bed of sand and calcareous grit. This is first seen a few hundred yards north-west of Little Bewbush, and from thence it ranges westward, by Hurst Hill, Gearing's, Little May's, Charman's, Honeylane Farm, Ridge Farm, Ironmonger Farm, Rudgwick, and the railway cutting north-east of Great House Farm, just west of Rudgwick.

From Rudgwick, south-westwards, the course of the bed is again uncertain. There is sand and a little stone at Aldfold, three miles west of Rudgwick; whilst on the south-west of Rudgwick, at Tisman's Common there is also sand, which may be on this horizon. Between Lock Farm and Marchall's Farm there is sandstone, and also at Oakhurst. Sandstone occurs at Billinghurst, and here this bed seems to join on to that which Mr. Martin has traced from near Kirdford, on the west, through Wisborough Green. From Billinghurst, eastwards, the course of the bed is by Dunken's Farm and Sandhill Farm.

No. 3. *Limestone.* (*Small Paludina Marble.*)—This bed is first observed at Idenbourn, 1 mile N.W. of Biddenden (Sheet 6), where it appears to be about one third (or 200 feet) up in the

clay. Only a 6- or 8-inch band was here seen; but the pit, now standing full of water, was probably dug for a lower layer. Further west it is known at Frittenden, Maplehurst Farm, Staplehurst (at Spill's Hill) and Great Pagehurst Farm. Beyond this, for several miles to the westwards, the Weald Clay flat is thickly covered with brickearth and gravel, and the marble is not known again until we reach Crowhurst; here it has been dug for roads near Bowerland Farm on the south of the village.

From near the last mentioned place westwards there is a well marked feature corresponding with the outcrop of this layer of limestone. At Gay House Farm it seems to be but one inch thick, at Lockland Farm, Outwood Common, three or four inches. It has been worked in the north by Stonehouse Farm, and is probably near the surface over the common. It is seen in the railway cutting, due east of Lady Farm. Here the line is broken by the low ground of the Mole: on the west of that river the feature recommences and winds south-west to Charlwood, the marble still cropping out along its southern slope. In the new road-cutting north of Charlwood it was six inches thick,—a hard blue shelly limestone. From this place, further to the south-west, the bed is perhaps not continuous; it is seen in the brickyard at Rug Hill, between Jarden's Farm and Evershed Farm, and again on the north of Rusper, the last place of its appearance, and here it is only two inches thick.

No. 4. Limestone. (*Large Paludina Marble:—P. Sussexiensis*, Mant.).—This, the lower bed of marble described by MR. MARTIN, is not known on the north of the Weald. It first occurs in a thin bed at Durfold Farm, just on the southern edge of Sheet 8, and 2½ miles south-east of Chiddingfold. At Shortlands Farm, near Plaistow, it was dug many years ago, from 10 to 12 inches in thickness. From hence it passes round to the south and south-east by Kirdford, and on the south of Billinghurst at Kingsfold and Slaughters. MR. MARTIN describes this bed as "the thickest and finest bed of Sussex marble, ... which used to furnish slabs for architectural purposes. At Slaughter-farm there are four layers, nearly alike in texture, separated by lines of a black ferruginous matter, and making in all about 18 inches."*

No. 5. Sand and Sandstone with Calcareous Grit.—The two beds of limestone last described are found, one on the north side of the Weald (No. 3), and one on the south side (No. 4). Although not precisely on the same horizon they will serve as the lower boundary of a group of sand beds now to be described. In Sheet 8 there are sections of sand in many places which cannot accurately be referred to their proper beds; all that we can say is, that they occur below the main bed of limestone (No. 7) and above the lower beds (Nos. 3 and 4).

Sand and sandstone are found in the eastern part of Sheet 6 not far above the small Paludina limestone north of Biddenden. At

* *Geological Memoir on Western Sussex*, p. 44.

Moat Farm and from thence westward towards Frittenden Green it has been dug, and it occurs on the north of Staplehurst between the railway station and Wantsuch Green.

From hence westwards there is a long gap in which it has not been observed, but no doubt it occurs there, for at the railway-cutting west of Batchelor's, two miles north-west of Edenbridge, there is sand and sandstone, 20 feet thick at least. It dips under clay on the north, and here the dip is 3° or 4°; at the southern end of the cutting the dip is 6°.

In the eastern part of Sheet 8, the bed which apparently represents this is thinner, but contains bands of calcareous sandstone, like Horsham Stone, and for this reason it is more sought after.

There are pits, from which this bed has apparently been dug, on the west of Burstow Park, and a little east of Mason's Bridge. Some fine blue grit occurs at the south-western end of Petridge Wood Common, and in the railway close by there is soft drab-coloured grit. From the River Mole for a few miles to the south-west the crop of this bed is pretty much parallel to that of the layer of Paludina limestone, which is marked on the map. It is known on the south-west of Wolver's Farm, at Norwood Place, on the north of Cudworth, at Newdigate Place, Mayland Farm, and on the north-east of Lyne House.

Hitherto there has been apparently but one bed of sand or stone at this horizon, but in the cutting of the Horsham and Dorking railway three are seen, and on the west of it there are the known outcrops of two.

In the cutting on the east of Lyewood Farm there is sandstone and grit, with a thin wedge-shaped bed of clay. The sand dips north, and is 15 or 20 feet in thickness.

In the cutting at Stilehouse Farm sand and sandstone are seen dipping north; here there are 20 feet of sand, perhaps more. Much of this is dark in colour, resembling decomposed grit.

At Capel Station there is a third bed, which is perhaps 30 feet in thickness; the dip is northerly, 2° or 3°.

In these cuttings the dip is generally to the north, though in some places the beds flatten, but there is no evidence of a repetition of the beds either by rolls or faults.

The places on the west where stone or sand occurs are as follows:—On the south at Bunnet's Farm, Den Farm, Rookham Farm, and at about a quarter of a mile to the north of Smokejack Farm. On the north a higher bed occurs at Islinghurst Farm, Evershed's Farm, Standing Farm, and Redfold Farm. This is probably the bed seen in the cuttings at Stilehurst Farm, and it may be continued on the west by the stone at Hyde Park and Bowle's Farm.

At Lodge Farm, Newhouse Farm, and Bridge Farm there is stone which is probably the prolongation of the southern bed. The sand seen in the railway cutting a little south of Lodge Farm is 20 feet in thickness. At Ewhurst there is sand which seems

to be higher in the series than either of these; it may be the same as that seen at Capel Station.

Further south-west there is sand and stone at Aldfold and Durfold Farm.

The southerly continuation of one or other or these beds has been traced by MR. MARTIN; it ranges nearly east-south-east from near Balls Cross towards Idehurst. At Andrew Hill it has been much quarried, and from here, paving stones, as fine as those at Stammerham, have been obtained.* It has been quarried in several places further east, near Shipley and West Grinstead.

No. 6. Limestone. (*Large Paludina Marble:—P. fluviorum*, Sow.).—This is the most constant bed in the Weald Clay and the most important. In different parts of its outcrop it goes by various names; as Bethersden Marble, Petworth Marble, Sussex Marble, Laughton Stone, &c. (*see* p. 368).

This bed occurs towards the top of the Weald Clay, probably about 100 feet down, but near Leith Hill it must be much lower. It often contains *Unio* and *Cypridea*.

It first "occurs at Hurst, beneath Court-at-Street, and seems to be continued in the clay which passes from that place round the base of Aldington Knoll." † This is in Sheet 4. In Sheet 3 it is known on the south of Daniel's Water at Freed Farm and Stanford Bridge. At Toosnod Green, just on the eastern border of Sheet 6, there are two beds of marble; an upper one of 7 or 8 inches and a lower one, not always present, of 5 inches. Here the outcrop is shifted to the north, perhaps by a fault, or by the slight change of strike which throws back the lower Greensand escarpment on the east of Egerton. The limestone is found again at Markhurst, a little north of Woodsden, and half a mile east of Pheasant Farm. Here the outcrop shifts south again to Headcorn. Just north of that village the limestone has been quarried with a thickness of 10 inches; but at one place it was said to be as much as 2 feet thick. Near Tilden it occurs, from 6 to 18 inches thick, splitting into beds of about 4 inches in thickness. At Hunton its occurrence was long ago described.‡

On Hadlow Common, due west of Goose Green, the limestone was found in draining. It occurs at Budd's Green; and was found in the Sevenoaks and Tunbridge Railway, 22 inches thick, sometimes in one bed, sometimes in two. A little west of this, on the north of Elsey's Farm, it is known; and again on the south of Tandridge.

In Sheet 8 the limestone is first seen near Redhill, where it crops out for about a mile along a small ridge called Kilnbrow, south of Earlswood Asylum. It was worked between the Asylum and the railway, where it was a rotten stone, 18 inches thick, from which the casts of the *Paludinæ* could be easily got out.

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* MARTIN, *Western Sussex*, p. 44.

† FITTON, *Trans. Geol. Soc.*, ser. 2, vol. iv. p. 161.

‡ HATLEY, *Phil. Trans.*, vol. xiv. p. 463 (1684). See also PROF. T. R. JONES, *Geologist*, vol. iii. p. 448.

The limestone is not known again till we come to the foot of the Leith Hill range, along the east and south of which it crops, through or near the following places:—on the north and west of Arnold House, Hen House Farm, Buckinghill Farm, Palmer Field, Lyefield Farm, Coophurst Farm, Woodland Farm, and Coneyhurst Farm near Ewhurst. A little to the north of the above-named places there is a bed of grit with dark pebbles, *Paludina* and *Unio;* it occurs at Brackspear's Farm, Trout's (west of Arnold House), between Bearhouse Farm and Broom Hall, and near Church Wood.*

Marble has been dug on the north of Cranley Common, and it is seen by the stream, three-quarters of a mile south-east of Chiddingfold; here it is 8 or 10 inches thick.

The outcrop of this bed of marble has been traced by MR. MARTIN in West Sussex;† it "varies in thickness from two to ten inches. Sometimes it is divided into two thin layers; at others it is concreted in one. . . . Fibrous carbonate of lime is found in it, and it is surmounted by a course of blue marl, which effervesces strongly with acids. It forms a tolerable road-stone in a country almost destitute of such materials.

"This course of marble may be distinctly traced through the whole line of country, from midway between Kirdford and Lurgershall, in the west, by Battlehurst and Marshalls, to the Arun, and by Pococks and Hungar-Hill, Hammer-pond-tail in Shipley, and Sands in West Grinstead parish to the Adur."

Further east "Sussex marble" has been noted by DR. MANTELL in several localities.‡ Considerable quantities have been dug along the Lewes railway, north-east of Blackbrook, and at Laughton. The most easterly point at which marble has been noticed is on Dicker Common, about three-quarters of a mile north of Upper Dicker. In all these places excepting Laughton we are not sure which kind of limestone occurs. That at Laughton is the large Paludina marble, occurring in a bed 6 or 7 inches thick, and is no doubt the same bed as that we have been tracing. The marble at the places mentioned by DR. MANTELL is probably the same.

A short distance below this main bed of limestone there is a thin bed with *Cyrena* and *Paludina fluviorum*, which appears to be of local occurrence. It was observed in the spoil-heaps from Bletchingley Tunnel, and at Henhaw Farm, a little to the west of the Tunnel.

No. 7. *Sand.*—This bed occurs in Sheet 3, where it makes a spread over the ground at Etchden Heath; here it is at least

* See DR. FITTON, *Trans. Geol. Soc.*, ser. 2, vol. iv. p. 160, "There the stone is a greenish micaceous grit, in three contiguous courses, each about 12 inches thick, containing very large *Paludinæ*, *Uniones*, and stemlike concretions, where the stone adjoins the whitish sand, on which it rests." I am indebted to the kindness of MR. D. D. HEATH, F.G.S., of Kitlands, for some information as to the outcrop of these beds.—W. T.

† *Geol. Mem. on Western Sussex*, p. 42 (and Map).

‡ *Fossils of the South Downs*, p. 65.

10 feet thick. It also occurs at Daniel's Water. At the western end of Sheet 6 there is a bed of sand not far above the limestone, cropping out a little to the north of it. It occurs on the west of Burnt Wood, at Warnden Quarter, on the south of Humphreys and elsewhere about here.

From this place there is a large area to the west in which no such bed has been noticed.* Just on the west of Earlswood Asylum there are about 6 feet of light brown loose sand with a little sandstone, and a little above this an irregular layer of impure limestone with *Paludina Sussexiensis* (?). Again there is a long gap, and then sand is seen in the road-cutting a little south of Hambledon Hurst, there is perhaps 15 or 20 feet of it. Sand is also seen in several places about Chiddingfold.

There is a bed of sand and sandstone seen in a brook just north-east of Oxfield Farm, west of Fernhurst, which probably is the same bed. There are about 15 feet seen, some of the beds are ripple-marked, and the sand is often rather coarser in grain than is usual with the Wealden sands. The Horizontal Section, Sheet 73, crosses the brook just here.

There is little doubt that this is the top bed of sand traced by Mr. Martin† :—"Sections have been made in it to the depth of 20 or 30 feet, and it is probably as much more. It is a brownish-yellow micaceous sand, abounding in white argillaceous veins, and with a coarse iron-rag,‡ sometimes containing casts of Cyclades, the teeth and scales of fishes, and vegetable impressions,§ and in every respect assimilating to what has been hitherto considered the true Hastings Sand. The course of this bed of sand has been particularly attended to, and it has been traced through all the line of country here attempted to be described. From Mulsey (in the line of section of the Arundel and Bognor Road), tracing it westward, it may be found at Bignor Farm, under Bedham Hill, Buckfold, Parkhurst, Lickfold, and within half a mile of Blackdown, near Lurgershall, where there is a fine bank of it exposed at Northurst Farm. Eastward, it runs by Willets and Spear Hill, and crosses the Worthing Road, at Wincaves, from whence its course is a good deal disturbed by the disruption of the vale of Greenhurst; but it is found at Jessups, and again, a little north of Henfield."

Of the course of this sand bed further to the east there is no information to give. Near Laughton there is some sand, and again in the northern part of Lower Vert Wood on the north of that

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* The water-bearing sands found in the Maidstone wells, about 100 feet down in the Weald Clay, may represent this bed.

† *Geol. Mem. West. Sussex*, p. 41.

‡ "The sand is sometimes sufficiently indurated to form a building stone. And the iron-rag frequently becomes a conglomerate of sand and clay, with angular, and sometimes slightly rolled fragments of chert and sand-stone. It has been extensively quarried in this part of the country, anciently, for smelting."

§ A specimen of *Endogenites erosa*, from this bed of sand, was found near Mulsey.

place, but this is below the layers of Sussex Marble, and probably represents No. 2 or 5.

On the south of Hailsham there is a good deal of sand, which seems to occur at about the middle of the Weald Clay, but its relation to the beds already described is not known.

F. DREW.
W. TOPLEY.

Note on the Punfield Formation.—We may here note a paper, which was published by MR. J. W. JUDD* in 1871, establishing as a distinct formation the alternating marine and freshwater beds which occur near the junction of the Weald and Atherfield Clays. The evidence for this classification has been mainly obtained on the Dorsetshire coast and in the Isle of Wight, but similar conditions obtained in our area.

The conclusion of MR. JUDD'S paper is as follows:—

"The grounds on which I have ventured to suggest that the strata, the nature and relations of which I have endeavoured to illustrate in the preceding pages, are worthy to rank as an independant formation, are as follows:—

"1. They present very distinct mineralogical characters, separating them alike from the overlying Neocomian and the subjacent Wealden Proper.

"2. They are of considerable thickness, attaining a maximum of 230 feet [at Atherfield].

"3. They present evidences of having been deposited under conditions differing alike from those of the Marine Necomian above and the purely freshwater Wealden below.

"4. They yield a considerable marine fauna (between 30 and 40 species being already known), which is remarkably distinct and well characterised.

"5. They are the undoubted representatives of a formation, which in Spain attains to a vast thickness, and which, alike from its marked palæontological characters, and its great economic value, is of much importance.

"6. Their relations to the Wealden and Neocomian are precisely analogous to those of the Purbeck formation, to the Oolite and Wealden, and they are therefore equally deserving with it of a distinctive title."

The alternations of marine and freshwater conditions which have already been described as occurring at Hythe (p. 98) are regarded by MR. JUDD as representing the Punfield Formation. He also has the following note upon Leith Hill: "In the Museum of this Society there is a series of fossils from Leith Hill, near Guildford,

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* *Quart. Journ. Geol. Soc.*, vol. xxvii. p. 207. See also the papers by MR. C. J A. MEYER, *Ibid.*, vol. xxviii. p. 252; and vol. xxix. p. 70.

accompanied by a section in which the marine beds at the base of the 'Lower Greensand' are represented as alternating with freshwater beds full of *Paludinæ* and other Wealden fossils. This series of fossils was presented to the Society by D. D. HEATH, ESQ." *

The beds immediately below the Atherfield clay at Haslemere, of which an account is given on p. 114, also seem to belong to the Punfield Formation.

* There is probably some mistake as to this matter; the fossils in the Geological Society's Collection from near Leith Hill are all freshwater forms, and they appear to have come from a point in the Weald Clay a good deal below the Lower Greensand.

CHAPTER IX.—LOWER GREENSAND (UPPER NEOCOMIAN).

In describing this formation we will take each sub-division separately and trace its outcrop from the coast of Kent westwards. The general characters of the divisions have already been given (see p. 4), we may therefore at once proceed to the detailed description.

Much of this and the two following chapters are transcribed from the notes and MS. of MR. DREW. Such paragraphs are marked as quotations by inverted commas.

ATHERFIELD CLAY.—This is first seen, at the lowest tides, opposite Shorncliffe battery; from thence, rising slowly westwards, it occurs along the line of inland cliff which extends from Hythe to Aldington Knowl. The beds of rag-stone in this cliff have very much slipped, thus covering up the clay. Strong springs are generally thrown out at its junctions with the Kentish Rag; the water of these springs is sometimes highly charged with bi-carbonate of lime.

The thickness of the Atherfield Clay appears to vary. In a shaft sunk by MR. F. W. SIMMS, near Hythe,* it was 49 feet 6 inches thick, and consisted of sandy clay, with indurated layers and some fuller's-earth. The beds here were very fossiliferous. Further to the west its thickness is less; probably not more than 15 or 20 feet near Ashford. Atherfield Clay, somewhat sandy and of a blueish and greyish colour, is seen below the Hythe Beds near Smeeth Station. Just west of Singleton Farm, near Great Chart, a road section shows:—

Blue Sandy Clay, with *Exogyra* and *Rhynchonella*.
Brown Clay.
Stiff blue clay (probably Weald).

Inliers of the clay occur at Leeds Abbey and Caring Street, the valley at the latter place reaches down to the Weald Clay. Stiff brownish clay is seen beneath the Kentish Rag at Loose, and the Atherfield Clay may also be traced some way down the valley. To the east it is faulted against the rag. This fault may be seen in the quarry face on the south of the valley, whilst on the north it appears to be indicated by a sharp bend in the hill-side. The stream, which beneath Boughton quarries flows underground, is brought to the surface by this fault. The stream flows above ground from Langley to Boughton quarries, along here the clay is probably not far from the surface.

"At Turkey Mills, east of Maidstone, a hole was dug in blueish black stiff clay, containing, I was told, large oysters. This was, no doubt, Atherfield Clay, and would seem to be about 20

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* *Proc. Geol. Soc.*, vol. iv. p. 206 (1843).

feet thick. Below this came blue shaley clay with shells of a species of *Corbula*;* this was probably Weald Clay. The railway cutting at Maidstone showed, as MR. BENSTED informed me, about 15 feet of Atherfield Clay. The cutting at Teston showed the following beds †:—

Clayey Sand.
Brown, rather sandy clay.
Blue shaly clay, with Cypris shales a few feet down.

"At a brickyard near Wateringbury Station brown clay with oysters occurs; and in the railway cutting below Nettlested Church there is blueish slightly sandy clay with two species of oysters and other marine fossils. Marine fossils were also found in blue sandy clay at the inlier by Witley Mills, south-west of Sevenoaks. At Penn Farm, south of Sundridge, shale was found in a ditch not far below the Hythe Beds; this appeared to be Wealden, and if so the Atherfield Clay is probably thin about here."

Sevenoaks Tunnel is in part driven through this clay. Many fossils are found in it and in the large concreted masses which the clay contains. At the northern entrance of the tunnel Atherfield Clay is seen faulted against the Hythe Beds.

In MR. GURNEY'S grounds, near Hungerford Farm, a thickness of eight feet of blue and brown sandy clay was found, and below it some masses of soft calcareous stone with marine fossils.

The railway S.E. of Redhill gave a section of these beds containing several large concretionary masses. A list of fossils collected here is given by DR. FITTON.‡

"At Woodhatch, near Reigate, a section in a brickyard showed the top beds of the Atherfield Clay, with clayey sand, passing down into sandy clay, which again becomes a purer clay a few feet lower.

"Hereabouts, and to the east, the thickness appears to be about 30 feet, but, from the fact that the Wealden shales in some places are at a greater distance from the sands of the Hythe Beds than before, it seems that the thickness gradually increases westwards."

The railway cutting near Park Farm, Dorking, showed the Hythe Beds passing down into the Atherfield Clay:—

Loose white sand.
Greyish brown sand, about 5 feet, clayey at the bottom,—passing into
Sandy Clay, brown above, sandy below,—passing into
Blue Clay.

"The Atherfield Clay may be seen at many places in the inlier near Guildford, though the greater part of that area is covered with gravel and sand. MR. GODWIN-AUSTEN, who in 1843 first drew

* Some species of *Corbula* are estuarine, some marine; possibly this section gave an example of MR. JUDD'S Punfield Formation (*see* p. 110).
† *See* SIMMS, *Proc. Geol. Soc.*, vol. iv., p. 406, for a note on the Teston cutting.
‡ *Proc. Geol. Soc.*, vol. iv. p. 201.

attention to these beds, notes its occurrence at the Arlington brickyard and near the ford at East Shalford,* and it may be seen along the stream between the latter place and the Powder Mills, and by the side of the road near Chilworth, where it is either a brown sandy clay or a more sandy blue clay. MR. GODWIN-AUSTEN tells me that the former is at the upper part and the latter below.† The thickness is about 60 feet, as to the west."

MR. C. J. A. MEYER ‡ has collected a large number of fossils from the Atherfield Clay at East Shalford, a list of which is given in Appendix I.

"The railway cutting at Witley Station and Haslemere gave excellent sections of the clay. At the former place its whole thickness was seen. The clay was in part sandy, in part rather stiff; it contained some nodules and thin layers hardened by calcareous matter.

"At Haslemere the beds were much disturbed and dipped at high angles, so that the whole of the Atherfield Clay was seen in the width of the cutting. The general section was as follows:—

Hythe Beds - -	Sand, passing gradually into the bed below.
Atherfield Clay - -	Tough brown sandy clay, 60 feet.
Weald Clay - -	Blue shale. Black shaly clay. Blue shale.

"A more detailed account, with a list of the fossils found, is given in the following note by the late MR. J. W. SALTER:—

'The change from dark greyish blue clay, full of freshwater 'or at least estuary forms, to the purely marine deposit of brown 'clay, was marked no less by the fossils than by the change in 'the colour of the bed.

'In the uppermost Wealden beds, *Melanopsis*, *Cyrena*, and *Cy-'pris* [*Cypridea*] were the prevailing forms. At the point of junc-'tion, very well seen by the side of the railway, abundant casts of 'worm-burrows marked the beginning of the new state of things, 'and these were almost at once followed by bivalve shells of the 'genus *Panopæa*, standing vertically in the silty mud as the 'living Panopæa does now. The lowest of these were within 'an inch or two of the dark shale.

'PROF. EDWARD FORBES in describing, with CAPT. IBBETSON, 'a like change at the bottom of the Atherfield section, in the Isle 'of Wight,§ says that the depression of the land must have been 'considerable, for the *Cerithia*, whose presence in the Upper 'Wealden beds showed the beginning of these marine conditions, 'were themselves destroyed by the further depression of the sea-'bed, and consequently greater depth (probably several fathoms) 'of the water. A short distance above these beds a peculiar shell

* *Proc. Geol. Soc.*, vol. iv. p. 171. A list of fossils from the Atherfield Clay ("Neocomian") is given in this paper.

† This difference of colour is perhaps owing merely to exposure, as is the case with other clays.—W. W.

‡ On the Lower Greensand of Godalming. *Geol. Assoc.*, Dec. 4, 1868.

§ *Quart. Journ. Geol. Soc.*, vol. i. p. 190.

'*Perna Mulleti* abounded, a species of large size with the hinge-
'line projecting like a horn.

'The case was quite similar at Haslemere, *Perna* and a
'*Nautilus*, with other shells, occurred a very little above the
'junction-line; and the list of fossils, which here follows is so
'like that of the Isle of Wight section that it might have been
'copied from the latter.

'On account of the absence of any layer of stone I have not
'attempted to draw a distinction between the lowest clay and
'the Perna-bed; but the following fossils were got (many of
'the best from the workmen), from all the beds together :—

MOLLUSCA.

Ammonites.
Nautilus pseudo-elegans, D'Orb., or *N. radiatus*, Sow., near the bottom.

Arca Raulini, Leym.
Astarte striato-costata, D'Orb.
Cardium. Two small species.
Corbula.
Cyprina. A species other than *C. angulata*, Flem.
Exogyra sinuata, Sow.
Gervillia anceps, Desh.
G. alæformis, Sow.
Lucina Arduenensis, D'Orb.
Ostrea.
Panopæa (*Myacites*) *plicata*, var. *mandibula*, Sow Shells standing vertically near the bottom.
Pecten.
Perna quadrata?
Pinna tetragona, Sow.
Trigonia caudata, Ag.
T. dædalea, Park.
T. dædalea, Park, var. *rudis*, D'Orb.

Discina. A small striated species, on the Exogyra.

ANNULOSA.

Annelid burrows. Abundant at the bottom.
Holaster (?).

CŒLENTERATA.

Holocystis elegans, Lonsd. This beautiful coral was pyritized in masses three inches across, and the shining mineral, filling up the interstices of the coral, gave it a brilliant lustre.

The DARK CLAYS of the WEALDEN contained :—*

Melanopsis tricarinata, Sow.
Cyrena elongata, Sow.
C. media, Sow.
Corbula.
Mytilus.
Cypridea spinigera, Sow.
C. tuberculata, Sow.
C. Valdensis, Sow.

J. W. SALTER."

Very little is known of the Atherfield Clay of Sussex. It appears to continue at the base of the Hythe beds to near Henfield, beyond which point it has not been separately coloured on the map. Perhaps some of the green sand just above the Weald Clay in sheet 5 may belong to this division (see p. 126).

MR. MARTIN † speaks of a "mixture and alternation of Lower Greensand at the base of the escarpment, and says the junction is also marked in some places by calcareous concretions with broken Ammonites, and other imperfect fossils." It "varies much in thickness. It is very trifling in the eastern part of the district, but increases rapidly westward. It may be studied well upon the northern slopes of Bedham-Hill and Flexham Park, and is there about the same thickness as in the well at Petworth-House, fifty feet." This well, the details of which are given by MR. MARTIN, gave, below the sandstone, white and "rocky sand" of the Hythe

* These are the beds which MR. JUDD has termed the Punfield Formation, see p. 110.
† *Geology of Western Sussex*, p. 40.

Beds, 35 feet of black sand underlain by 15 feet of brown sand; below this came Weald Clay.

This well-section has been misunderstood, and too great a thickness has been assigned to the Lower Greensand. It was correctly interpreted by MR. MARTIN. The following are the divisions according to the Geological Survey nomenclature :—

		Ft.	In.
Lower Greensand, 115	Hythe Beds	65	0
	Atherfield Clay	50	0
	Weald Clay	285	0

At the Stopham brickyard, near Pulborough, Lower Greensand shells (*Panopæa plicata*) were found at the top of the Weald Clay with *Cypridea*, *Cyclas* (*Cyrena*), &c. DR. FITTON, in his description of the fossils from Stopham, speaks of some of them being inclosed in masses of phosphate of lime.*

HYTHE BEDS.—MR. DREW's description of this division, upon the coast of Kent, is as follows† :—

"The Hythe Beds are interstratifications in about equal proportions of limestone and sand. The former is close in texture, has a grayish blue colour and contains fine grains of quartz; the latter is for the most part drab-coloured, impure, rather clayey, and somewhat calcareous; the stone goes by the name of "rag," while the intermediate sandy beds are called "hassock." The beds which reach a thickness of about two feet are chiefly used for building, thinner ones are burnt for lime, and considerable quantities of the rag are used as roadstone. The following sections give an idea of the way in which the stony beds occur :—

"In the cliff between Hythe and West Hythe, an old quarry shows three courses of stone, two feet thick, nine thinner ones, and hassock, making up a total thickness of 18 ft.

"At the quarries above Hythe, 14 courses of stone from one to two feet thick, with layers of hassock from six inches to three feet thick, make together 40 feet of strata.

"In the lower part of this subdivision the beds are apt in quarryman's phrase to be more "hassocky," and the sand sometimes contains spheroidal concretions of stone, as is the case below Lympne, and there are also some beds of softer stone, full of dark green grains. The uppermost strata are usually irregularly bedded, more brown than blue in colour, and they are often rich in fossils, well seen, for instance in a small quarry at Pedling, and in another a little west of the Sluice House."

The total thickness of the Hythe Beds or Kentish Rag is about 60 feet.‡ From the Kentish Rag a large assemblage of fossils has

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* FITTON, *Trans. Geol. Soc.*, ser. 2, vol. iv. p. 156.

† F. DREW, *Mem. Geol. Survey*, sheet 4, p. 7 (1864).

‡ MR. SIMMS (*Proc. Geol. Soc.*, vol. iv. p. 207) gives the thickness as 129 feet. This I believe to be incorrect; it was "ascertained by combining the results of several different borings."—(W. T.)

been obtained in the quarries immediately above the town of Hythe, and those at Lympne, W. of Hythe. The lists of fossils given in the Appendix have been prepared by MR. ETHERIDGE from observations and notes made upon the spot, and also through the liberality and assistance of MR. MACKESON, who placed the whole of his collection at the disposal of the Geological Survey. The fossils from Lympne were originally in the collection of MR. HILLS, of Court-at-Street, but are now arranged in the Museum of Practical Geology in Jermyn Street.

The small outlier at Aldington Knowl shows clayey sand, with a little soft stone; these are the lowest beds. Somewhat higher in the series is the quarry near Aldington Church, where there are five courses of stone, each from 12 to 18 inches thick. At Clap Hill is a small quarry, the stone of which is rarely good enough for building, and is mostly used for roads and lime burning. The railway cutting just west of Smeeth station shows the Hythe beds, resting on Atherfield Clay:—

		Ft.	In.
Hythe Beds	Soft yellowish stone	1	0
	Brown clayey sand	8	0
Atherfield Clay	Grey sandy clay	4	0

Good sections are seen in some quarries half-a-mile south-east of Great Chart. The stone here is a good close blueish limestone, in beds from 6 to 44 inches thick, alternating with beds of "hassock." In the quarry by the roadside, going N. from Four Elms, the Sandgate beds are seen above the "rag" (see p. 129). Fossils are more abundant in this quarry than in most others in the neighbourhood.

"About Maidstone the whole of the Hythe Beds consists of beds of 'Kentish Rag,' with 'Hassock' between the layers. The hassock is either a coarse impure looking sand, or, when harder, a whitish soft calcareous stone. For two thirds of the way down the beds of stone are generally about one foot thick, but are sometimes only six inches, and sometimes as much as two feet thick. They are interstratified, with about an equal thickness of Hassock, and there is now and then a layer or a lenticular bed of dark chert. Then comes a layer which MR. BENSTED has traced over some considerable area; it is a bed of hard, fossiliferous hassock, containing *Exogyra*, *Trigonia caudata*, &c. Below this is a good hard hassock (sometimes used for building), and a little of the true limestone."

These beds may be well seen in the Iguanodon quarry* at Maidstone, belonging to MR. BENSTED. Other good sections are those north-west of Little Buckland, and at many other places near the high road. Very large quarries, now abandoned, are seen near Allington Church.

Just west of Otham Church are large old workings, where the stone has been got by driving levels into the rock; many of the caves thus formed are still open.

* So called from a very fine specimen of the *Iguanodon*, discovered here by MR. BENSTED, many years since. This fossil is now in the British Museum. This quarry (and the geology of Maidstone generally) has been described by MR. BENSTED. *Proc. Geol. Assoc.*, vol. i. (No. 5) p. 57, and *Geologist*, vol. v. p. 334, 378.

In the rag is often found dark phosphatic and carbonaceous masses of small size, which MR. BENSTED supposes to have been the fleshy parts of Mollusca. This substance was described by DR. MANTELL as "Molluskite." It contains much phosphate of lime, and "35 per cent. of its own weight of carbon in an organised state."* Considerable quantities are sometimes found scattered through the layers of stone, but never in sufficient abundance in any one bed to be of economic value for its own sake.

Wood and coniferous fruits occur in the rag at Maidstone, but have chiefly been collected at the Iguanodon quarry by MR. BENSTED. The following species occur there† :—*Pinites Mantelli, P. Patens, P. Benstedi.*

The museum at Maidstone contains many specimens of fossils from the rag-quarries and a large series of specimens of *Siphonia*, collected by MR. BENSTED.

Near Maidstone this division is about 80 feet in thickness.

"Most of the quarries in the neighbourhood of Maidstone show the same general characters; it may therefore suffice if two sections are given in detail.

"*Section at Boughton Quarries.*

	Ft.	In.
Irregular layers of Hassock and Rag	8	0
Hassock and concretions of Rag	1	6
Rag	1	0
Hassock	0	8
Rag, with a thin band of Hassock	1	6
Hassock, with some concretions of Rag	1	6
Rag	1	0
Hassock	1	3
Rag	1	0
Hassock, with a lens of Chert	2	0
Rag	1	10
Hassock	1	2
Rag	1	0
Hard Hassock	0	6
Rag	0	6
Hassock	0	10
Rag	0	4
Hassock	1	0
Rag	1	2
Hassock	1	0
Rag	0	10
Hard Hassock	0	8
Rag	1	0
Hassock	1	9
Rag	1	9
Hassock	0	6
Rag	1	0
Hassock	0	6
Rag	0	6
Hard Hassock	1	0
Rag	1	0
Hassock	2	0
	41	3

* *See* MANTELL, *Proc. Geol. Soc.*, vol. iv. p. 36.

† *See* CARRUTHERS, *Geol. Mag.*, vol. iii. p. 534, and the references there given.

" *Section near Preston Hall, South of Aylesford.*

	Ft.	In.
Hassock, with lines of Chert and Rag	6	0
Rag, with a little Chert in places	3	6
Chert		
Hassock		
Rag		
Hassock, with a thin layer of Rag	2	6
Rag	1	3
Hassock	0	9
Dark Chert	1	3
Hassock	1	0
Rag	1	0
Hassock	1	0
Rag	1	0
Hassock	1	3
Three layers of Rag, separated by thin Hassock	3	0
Hassock, with a thin layer of Rag	2	6
Rag	0	9
Hard Hassock	0	6
Rag	0	9
Hard Hassock, with many fossils in the lower part	1	9
Rag	1	9
Rag	1	0
	32	6

" At Sevenoaks the Hythe Beds contain a hard, brittle, light brown *chert*, with the original sandy structure just visible, this varies in thickness from 4 to 15 feet; *Hassock*, with a few lenses of limestone, and below it limestone (Kentish Rag) in greater proportion. The *Rag* is of a blueish-grey colour, crystalline, with many grains of sand; and sometimes contains small pebbles. There are layers of softer limestone, with a harder hassock between: here, in fact, the rag and the hassock become more like each other; both are dug for building.

" The first kind of stone, the chert, is called Sevenoaks Stone; it is much used for roads, being carried great distances, far into the Weald, for this purpose. It occupies the surface along the top of the Greensand plateau, from Brastead Chart to some three miles beyond Sevenoaks Common; and further east, in Great Comp and Malling Woods, the ground is covered with a similar stone, which must occur in some layers below."

At the northern entrance to Sevenoaks tunnel is the following section:—

	Ft.	In.
Angular Chert and Loam		
Sand, with a few thin beds of weathered Rag and Chert.		
Rag	1	0
Hassock	2	0
Rag	1	6
Hassock	2	0
Rag	0	9
Hassock	2	6
Rag	2	0
Hassock	3	0
Rag	1	6

	Ft.	In.
Hassock - - - - - -	4	0
Rag - - - - - -	1	0
Hassock - - - - - -	3	0
Rag - - - - - -	2	0
Hassock - - - - - -	5	0
Rag - - - - - -	1	0
Hassock - - - - - -	2	0
Alternations of Rag and Hassock for about -	40	0
	74	3

If this section be compared with those just given from the Maidstone district, it will be seen that there is considerably less Rag here than in the country further east. West of Sevenoaks it diminishes still more rapidly.

The railway-cuttings just north of the tunnel show a very fine section of Hythe Beds, with Atherfield Clay faulted against them.

The beds of ragstone are tolerably constant at Sevenoaks, but very soon in tracing them westwards we find them becoming irregular in thickness, and frequently they are only lens-shaped masses imbedded in hassock.*

"Towards Westerham the lower part of the Hythe Beds is mainly a soft sandstone containing many green grains, with some hassock, whilst above it is more calcareous and still contains some rag. At Limpsfield the upper part consists of sandstone, which continues on to the west, excepting that at Oxtead there are some indications of limestone again on this horizon, but such have not been observed west of this. Sandstone is again seen at Tandridge, and to the north of Tilburstow Hill; south of this the road cutting shows the structure of the beds below: chiefly sand with wavy bands of siliceous ironstone.

"The Hythe Beds vary in thickness throughout this area, being thinnest where they contain most calcareous matter. At Maidstone they are 70 or 80 feet thick; about East Malling probably about 100, and at Sevenoaks 160. At Sundridge a well proved them to be 180 feet, and from hence westwards they slightly increase in thickness."

From Limpsfield, westwards, for about 17 miles, the outcrop of the Hythe Beds is very much narrowed, being generally less than half-a-mile in width.

The road cutting at Tilburstow Hill shows a good section of this division.† The lower part consists of grey and iron-shot sands with irregular ferruginous lines and some chert. Higher up the hill there is this section:—

	Ft.	In.
Chert.		
Clayey sand, inclining to stone in places, hardened into iron-sandstone below - - - - - -	6	0
Sand and clayey sand, with chert and iron-sandstone; the upper part is sometimes greenish and sometimes a mottled clayey sand - - - - - -	40	0

* Several sketches of quarries and road sections west of Sevenoaks are given by Dr. Fitton, who describes a line of disturbance through the Hythe beds for some miles along here. See *Trans. Geol. Soc.*, ser. 2, vol. iv. pp. 133–135.

† Dr. Fitton gives a detailed section of the beds exposed at Tilburstow Hill.

The old road cutting, further north and just east of the present road, shows the top beds; they here consist of sand and soft sandstone in thin beds. The sands are sometimes greenish, and the sandstone is sometimes cherty.

Similar sections are seen in many of the lanes leading from the high ground to the Weald.*

"In the railway-cutting just south of Redhill Station there is brown sand with ironstone, underlain by 50 feet of yellowish-brown and drab sand.

"By the roadside at Cockham Mills there are 30 feet of rather coarse sand with some thin ironstone. About Reigate Heath the beds are sandy throughout, and in Betchworth and Deepden Parks there is some sandstone. In several places south and south-west of Dorking the beds are seen. Generally they are sands with ironstone; in the road near Holloway Farm there is buff sand, partly calcareous, with thin beds of clay, overlying sand with layers of ironstone." The railway cutting east of Dorking exposes a fine section of these beds.

On the south-west of Dorking the Lower Greensand country shoots suddenly out to the south, the enlarged area being chiefly occupied by Hythe Beds. A change in composition also takes place about here. There is more sandstone in the beds; and in the higher part there appears a calcareous sandstone or grit, known as "Bargate Stone." This is found in greatest force in the country lying north-west of a line drawn from Shiere through Highdown Heath to Witley, and here the sandstones are of least importance, decreasing westwards; whilst on the south-east of this line the sandstones occur in quantity and the amount of Bargate stone is small.

The sandstone beds take up the chief part of the sloping plateau that stretches northwards from the escarpment at Ridland Hill, Leith Hill, and Hurtwood Common; they are best seen at the following places:—

"The lane northwards of Collickmoor Farm gives a section of ten feet of sand and sandstone, showing false-bedding, an uncommon thing in the beds with sandstone though very general in those with Bargate Stone.

"At Cold Harbour some quarries show 25 feet of yellow and light brown sandstone, speckled with green, and in parts with streaks of a dark purple matter, in beds of from a foot to three or four feet thick.

"In a large quarry at Coneyhurst Hill there is this section:—

	Ft.
Equal proportions of sand and sandstone, in beds of from 6 inches to 2 feet thick - - - - - - -	30
Thick beds of sandstone - - - - - - -	15

"There are here a few layers of chert. Close by, a road-side section shows lower beds: light-coloured sand with a few globular

* The higher part of the Hythe Beds, near Nutfield is noted on p. 182.

concretions of ironstone. There is interbedded sand and sandstone with some chert and ferruginous stone in a road-cutting just west of Ewhurst Mill.

"Quarry half a mile east of Bearland Farm:—

	Ft.
Sand, with a little sandstone - - - - -	6
Yellow sandstone, with 5 beds of chert, each 3 or 4 inch thick -	6
Yellowish green-grained sandstone, 3+2+2 feet thick - -	7

"Bargate Stone, which is first seen in a soft state a little east of Wotton, occurs at the top of the sands a little west of Abinger Hall; there is sandstone beneath, which continues for a long way down, as is shown by the outcropping of lower beds to the south.

"Godalming is the central country of the Bargate Stone, it is here quarried in many places. The quarry and road-cutting at Holloway Hill give the following section:—

	Ft.
Coarse light-brown or buff sand, much false-bedded, with beds of hard calcareous sandstone or grit - - - -	30
Buff calcareous sand - - - - - -	46

"The stone is in beds of from six inches to three feet thick, often cut off by a plane of false-bedding: some of it is soft and not fit for building, some very shelly and some sparry. I was told that the stone-bearing beds were 40 feet thick from top to bottom.

"There is a like section at Eashing, on the right bank of the River Wey, showing hard beds above and soft sand below, and the same may be seen in many of the deeply cut lanes within a few miles of Godalming.

"Near the top of the Hythe Beds, and either above or in the Bargate Beds, are some ferruginous sands of no great thickness, which may be seen near the south-eastern corner of Highdown Heath, at about half-a-mile east from Busbridge, and in several places on the north-east.

"In a pit in Bargate stone just west of where the *A* of *Artington*, near Guildford, is engraved on the map, there is a bed 18 inches thick of soapy clay or fuller's earth; higher up there is more of the same in the oblique laminæ of a sandy bed. Another pit, half-a-mile to the east, shows some very coarse calcareous grit, approaching to conglomerate.

"The following very good section of the whole of the Hythe Beds may be seen in the lane west of St. Martha's, and leading to Halfpenny Farm:—

Folkestone Beds -	Ferruginous sand.
Sandgate Beds -	Clayey sand, with large pebbles and small patches of fuller's earth.
Hythe Beds -	Brownish-grey sand, with ironstone. Very coarse dark sand, consisting of grains of brown ironstone. Brownish-grey sand. Sand, with Bargate stone, and a few thin layers of fuller's earth. Some way lower down. Ferruginous sands. Buff sands, not ferruginous.

"The loose ferruginous sands somewhat east of Little Tangley I take to be about 20 feet down in this division.

"Bargate stone occurs along the steep slope on the right bank of the Tillingbourne stream between Weston Street and Chilworth. In this part there is some sandstone below the calcareous beds, as may be seen in some of the lanes and in a railway-cutting.

"On the south-west of Godalming there are sections in the following places. Near Hambleton Church sandstone with green grains may be seen, and most likely it occurs along the greater part of the escarpment between that place and Nore Farm. Above Burgate,* from which DR. FITTON suggests that the name may have been taken, I could neither see nor hear of any Bargate Stone; the beds there are probably sandstone and sand.

"In the railway-cutting near the mill at Witley there is Bargate Stone, and in the road-cutting half-a-mile south-east from Munsherd Farm the beds shown are:—

Bargate stone.
Sand, with thin courses of sandstone.
Light brown sand.

The lowest beds are very sandy and contain ironstone like that of the Folkestone Beds. They may be seen in the cutting near Witley Station and are there:—

	Ft.
Orange yellow sand, with thin plates of sandy ironstone -	30
Whitish-brown sand, without any oxide of iron - - -	12

"Rather higher up than this the cutting of the road leading up to Hambleton shows 40 feet of very light-coloured sharp sand."

The Hythe beds are about 200 feet thick at Leith Hill, and perhaps 240 or 250 around Godalming and Guildford.

MR. C. J. A. MEYER, who has carefully studied the Lower Greensand of the neighbourhood of Godalming, places, without any doubt, the Bargate Stone with the overlying sand of the Folkestone Beds. Beneath the Bargate Stone there is often some coarse sand with pebbles, which MR. MEYER regards as the base of the upper division lying unconformably on the beds below.† In placing the Bargate Stone with the upper sandy division, MR. MEYER agrees with SIR R. MURCHISON.‡

DR. FITTON,§ however, to whom the whole district to the east was intimately known, regarded it, with some probability, as part of the lower division, or Hythe Beds. Whatever opinions may be held upon this point the "pebble bed" and its fossil contents are of very great interest. I extract the following from MR. MEYER'S paper:—

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* Engraved *Burgh Gate* on the Map. The common pronunciation is a very natural contraction of this.

† "On the Lower Greensand of Godalming." A Paper read before the Geologists Association, London, Dec. 4th, 1868. See also *Geologist*, vol. vi. p. 52, vol. vii. p. 5; and *Geol. Mag.*, vol. i. p. 249.

‡ *Trans. Geol. Soc.*, ser. 2, vol. ii. p. 101.

§ *Ibid.*, vol. iv. p. 146.

"The *lower layers* of this pebbly stratum, or Pebble-bed, as I have elsewhere called it, are usually the coarsest in composition, and appear to rest unconformably upon the sands beneath, or even occasionably to fill up small pockets or depressions in the underlying sand-beds, as if resting on an unequally eroded surface.* The *upper layers* contain fewer and smaller pebbles, and pass more or less gradually into the gritty sands of the Bargate-stone group above.

"The thickness of this *pebble-bed* varies considerably, ranging in the district around Godalming, from a few inches to 10 or 12 feet."

"Mineralogically the pebble-bed consists of coarse quartzose sand and waterworn fragments of many kinds of rock.

"It is also partly made up of extraneous fossils,† namely—fragments of casts of *Ammonites*, and other small Univalve and Bivalve shells; teeth of *Saurians*; teeth and scales of *Fishes*; fragments of *Pentacrinites*, &c. Some of these have been recognized as fossils of older rocks—such, for instance, as *Ammonites Lamberti* and *A. crenatus*, of the Oxford Clay. Others, and amongst them all the small univalve and bivalve shells, I have been wholly unable to identify. Yet, with exception of the several species of *Brachiopoda* and two or three species of *Pecten* and *Exogyra*, which will be presently mentioned as also occurring in these beds, the whole would appear to be *extraneous* (*Oolitic* and *Liassic*) fossils which had been drifted into their present position *at the time of the deposition* of the strata in which they now occur.

"Fossils are extremely scarce in the Bargate Stone around Godalming, and in some quarries are not to be found at all. Most of the specimens enumerated below are from a quarry a few hundred yards to the west of St. Katherine's Hill, near Guildford. . . . . The small species of *Avicula*, *A. pectinata*, Sow. is especially a *Bargate-Stone* fossil. It occurs abundantly on the same horizon at Nutfield,‡ Reigate, and Folkestone, but is not found at a lower level in the Greensand."§

Mr. Meyer has noticed phosphatic nodules with casts and impressions of fossils in a road-cutting near the railway-bridge, Godalming.

In the Hindhead district the Hythe Beds attain their greatest known thickness, which, at the Devil's Punch Bowl, cannot be much less than 300 feet, for the top beds are there denuded. In this district the beds lose most of their distinctive characters, and

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* I do not see that the appearances above described necessarily indicate unconformity, or a break in the succession of deposit. My former colleague, Mr. J. W. Judd, who examined the sections with Mr. Meyer's paper in his hand, is of this opinion, and regards them as simply cases of false-bedding.

† See also Mr. Godwin-Austen's Paper, *Quart. Journ. Geol. Soc.*, vol. xii. p. 71.

‡ See p. 131. The beds here referred to Mr. Drew considered to be Sandgate Beds.

§ The foregoing quotations are from pp. 10, 13–17 of Mr. Meyer's paper; his lists of fossils from the "Pebble Bed" and the "Bargate Stone" will be found in Appendix I.

much resemble the overlying sands of the Folkestone Beds. The middle clayey division is absent too on the north of Hindhead, but it reappears near Headley.

Bands and nodules of Bargate Stone continue to occur in the higher part of the Hythe Beds, but they are of far less importance than near Godalming, and probably disappear for some distance at the western angle of the country. They serve, however, to connect the beds of Godalming with their probable calcareous equivalents near Pulborough. Bargate Stone occurs east and west of Thursley; and in the railway cuttings near Lake House and Liphook, there are sands and sandstones with a little blueish Bargate Stone and chert. The crumbly nodules of Bargate Stone in the cutting north of Rake are fossiliferous; these occur just below the Sandgate Beds.

All over this district the lower beds are mainly sand with some soft yellowish sandstone. About Lynchmere there is some chert and cherty sandstone; a little fuller's earth occurs in places; a thin bed was met with in a well near Haslemere.

Starting now from the sharp angle of the Lower Greensand escarpment at Harting Combe, and tracing the beds westwards through Sussex, we find at first the same general absence of hard beds already noted; but in proceeding westwards the sandstones in the lower part, and the calcareous beds in the higher part, increase in importance. Both reach their greatest development in the neighbourhood of Pulborough, and hereabouts too, as we shall presently see, the Sandgate Beds can best be studied.

False-bedding occurs occasionally in these beds, instances of which may be seen near Chithurst, in the road north of Cumbers Farm, and in that south-east of Hammer Pond.

The thickness decreases from west to east. Near Midhurst it may be about 200 feet. The bands of calcareous stone in the upper part of the Hythe Beds are well seen in the road one mile north of Midhurst. Here the stone is in largish concretionary masses in the sand, not in constant beds; it very much resembles some kinds of Kentish Rag, and is finer in grain than the Bargate Stone. It contains dark grains and "Molluskite." Chert is dug for roads in many places over the common on the north of this, and the slightly greenish sandstone which occurs lower down may be seen on the face of the escarpment. This stone has been much quarried at Petworth and near Pulborough.

Fuller's earth still occurs in small quantities, generally in the lower part of the Hythe Beds; it has been dug near Tillington.

The chert* has been dug on the high ground east and west of Petworth. It also occurs associated with the sandstones below.

Near Pulborough the calcareous stone may be seen in many places. The railway-cutting where crossed by the main road shows nodular masses of limestone imbedded in sand, and below

* Called "whinstone" in this district. In the Newcastle and Leicestershire Coal fields this term is applied both to basalt, sometimes called "blue whin," and to the harder beds of quartzose sandstone, which are called "white" or "grey whin."

them a bed of the same stone. In a quarry north of Home Street the same thing is seen; there are two layers of nodules and a bed of very hard blue rag below, one foot thick.

An excellent section of these beds is exposed in the road going south from Roundabout Farm near Thakeham. The beds of stone are in part lenticular. The stone is not very good, resembling inferior varieties of Kentish Rag. The sand and soft sandstone between, very closely resemble the "Hassock" of Kent, and as such I shall describe it, for it is neither sandstone nor sand. The section is as follows:—

	Ft.	In.
Rubbly stone - - - - -	2	0
Hassock - - - - - -	2	0
Stone - - - - - -	1	6
Hassock - - - - - -	3	6
Stone - - - - - -	1	0
Hassock, with 6 inches of stone - -	2	6
Stone - - - - - -	1	6
Hassock, with 6 inches of stone - -	4	0
Stone, an irregular bed - - - 2 ft. to	3	0

Hassock and stone are seen below, the latter decreasing in quantity as we descend. The lower sandstone beds are not exposed in this section.

The raggy beds are seen again near Ashington, but to the east of this place they disappear. The lower sandstones also become less important in this direction. The beds are well shown at Henfield, and there the lower part consists of beds of hard, rather greenish, sandstone, divided by hassocky sand.

Still further east the hard beds disappear and the Lower Greensand is no longer divisible into its usual members. The dividing lines have, with some doubt, been prolonged into Sheet 5 along their probable horizons,* but the middle group (Sandgate Beds) cannot be satisfactorily traced east of Hassocks Gate (see p. 138).

In Sheet 5 the Lower Greensand is much reduced in thickness (50–70 feet) and consists of reddish, greenish, and whitish sand, apparently without any hard beds, but sections are rarely seen. The lowest parts, near the junction with the Weald Clay, is a very green clayey sand, possibly representing the Atherfield Clay, though of this we cannot speak with certainty. It may be very well seen at Week Green, east of Chalvington, and also on the east side of Bourn Level.

Some small sections and wells are noted by DR. MANTELL.†

In the description of the Folkestone Beds and Gault in subsequent pages of this Memoir, frequent mention will be made of phosphatic nodules at the top of the Lower Greensand and the bottom of the Gault. They are found in this district, although absent for some miles along the outcrop on the west. Their

* These lines should be dotted on the map, they have been engraved strongly in mistake. This is also the case with the lines on the south side of the Greenhurst Anticlinal in Sheet 9, they should be dotted from near Buncton Chapel on the west to Woodmanton on the east.

† Fossils of the South Downs, pp. 75, 76.

re-appearance here is interesting, as they are found on the same horizon in the Lower Boulonnais.

The junction may be seen in the railway cutting west of Polegate Station, south of Wooton Farm. Here the Gault with its phosphate bed and fossil wood lies on the sands of the Lower Greensand. The same cutting also shows nodules *in* the Greensand:—

	Ft.	In.
Green, rather clayey sand - - -	1	6
Phosphatic nodules and wood - - -	0	4
Red sand - - - - -	1	0
Sand, setting greenish below.		

The following note has been supplied me by MR. BRISTOW:—

"In a sand-pit by the road-side at the corner of Selmeston Churchyard, there is a very interesting section to which my attention was directed by the REV. OSMOND FISHER. It seems to me to be the junction between the Lower Greensand and the Gault. The first-named formation is here represented by whitish or greenish-white sands or soft sandstone crowded with green grains, and in colour about the same as many of the pale beds of the Upper Greensand. They are buff-yellow in places. The upper part of these sands is slightly irregular and uneven, and is sometimes stained of an ochreous-brown colour, owing to the presence of peroxide of iron. The Gault is represented by dark olive-green clayey sands, which also become ochreous-brown by exposure. Between the two sands, and forming a sort of passage-bed, are about 6 in. of ferruginous and grey sands, irregularly mixed and without any particular arrangement. In it occur small occasional nodular concretions of various sizes and of irregular shapes, which appear to be phosphatic, and in some instances to be converted into iron-ore. There are, also, numerous fragments of fossil wood, but no other fossils were observed. The same gault containing wood is present in the deep well at the Warren Farm, near Brighton, where it forms the lowest 10 feet of that formation."

This is probably the section noted by DR. MANTELL* and from which he obtained the fossil named by him *Zamia Sussexiensis*, but which MR. CARRUTHERS† describes as *Pinites Sussexiensis*, nearly allied to *P. Strobos*, L. MR. CARRUTHERS says, "The specimen which is, as far as I know, still unique, was found in the Lower Greensand at Selmeston, Sussex, in a bed along with water-worn fragments of stems and branches, which are generally more or less perforated by boring mollusca."

MR. RALPH TATE informs me that the Lower Greensand may be seen at Langley Point at low water; DR. MANTELL also mentions this.‡ I have looked for this, but have not been fortunate enough to see it, possibly from not having been there at lowest tides.

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* *Quart. Journ. Geol. Soc.*, vol. ii. p. 51.
† *Geol. Mag.*, vol. iii. p. 541.
‡ HORSFIELD'S "History of Sussex," vol. i. p. 16.

SANDGATE BEDS.—In East Kent "the general composition of the Sandgate Beds is dark clayey sand and clay, the dark colour being chiefly due to the presence of numerous green particles of glauconite (a hydrous silicate of iron and alumina).

"The colour of the whole approaches to blue or green according to the predominance of clay or sand. These characters are perhaps best seen in the bank by the side of the military road leading up to Shorncliffe Camp, and below the undercliff, east of Sandgate, where beds of bluish clay a foot or two thick alternate with equal beds of clayey sand.

"The generally clayey nature of the strata is proved by a line of springs marking their junction with the sands above.

"Here and there concretions of a soft green-grained calcareous stone are found, examples of which occur at Pedling and in the bed of a brook in Sandling Park; and spherical concretions of brown ironstone containing many fossils (like those that occur at Shanklin in the Isle of Wight) have been found above the village of Sandgate. As in many other clays, crystals of selenite are not uncommon. The thickness of the Sandgate Beds is about 80 feet."*

Some shafts sunk in the Lower Sandgate Road, Folkestone, showed dark slate-coloured sandy clay, without fossils; when cut by the hammer the surface was sometimes green, sometimes blue.

On the shore a little east of Mill Point is the following section: —

		Ft.	In.
Greenish Sandstone, weathering brown - - -		1	0
Clayey Sand, slate coloured in mass, but very green when cut by the hammer; interbedded below with thin layers of sand - - - - -	18 to 24		0
The lower part of this bed is often concreted into large lenticular masses, 18 inches thick, showing on the weathered surface curious markings, somewhat worm-like, but twisted about and intermixing. These markings weather brown and stand out from the mass which weathers light green.			
Clayey Sand, slate coloured at top, but greenish below -		2	0

Saltwood Tunnel is partly driven through the upper part of these beds. MR. SIMMS describes them as clay, "dark green, tough and adhesive, almost black when first brought to the surface, and containing very little sand."† Much water was found at the junction with the Folkestone Beds, and about 10 feet below there was some resin of a clear red colour.

At the western corner of three roads just W. of Saltwood Castle some small pebbles are seen *in* the Sandgate Beds. They occur

* DREW, *Mem. Geol. Survey*, Sheet 4, p. 9. The beds, which are exposed at lowest tides on the east side of Folkestone Harbour, are probably Sandgate Beds. They are described on p. 139.

† *Proc. Geol. Soc.*, vol. iv. p. 206 (1843). See also *Practical Tunnelling*, 2nd edition (1859). MR. SIMMS' estimated thickness of these beds is, I believe far too great. The data for his estimate are given at p. 207 of the former Memoir; on comparing the description ["*b*"] with the table below (where the "middle division" is given as 158 feet thick), it seems probable that the latter number is given 100 feet in excess.

with ferruginous sand and overlying clayey sand. MR. MACKESON tells me he has seen clayey sand also above them.*

The junction of the Sandgate Beds with the Hythe Beds beneath occasionally exhibits characters closely resembling those of the junction of the Gault and Folkestone Beds; viz., phosphatic nodules and pebbles, with fossils in fragments or casts, and bored wood.

A small quarry at Grove Bridge shows the following section:—

	Ft.	In.
Brown and Green clayey sand - - -	4	0
Clayey sand, with small quartz pebbles and small nodules - - - - -	0	4
Greenish clayey sand - - - -	1	6
Layer of nodules and bored wood, with fossils	1	0
Greenish clayey sand - - - 2 ft. or	3	0
Rock.		

These nodules are not constant, for some other sections in the immediate neighbourhood do not show them. In this respect the junction is unlike that at the base of the Gault, where the nodules are remarkably persistent. In some sections seen on the hill side between Hythe and Shorncliffe, the nodules are apparently replaced by ferruginous layers and concretions.

Near Great Chart, at a quarry by the road-side north-east of Four Elms, the phosphatic nodules are very numerous. The section shows:—

Green sandy clay.
Phosphatic nodules, in a bed about 1 foot thick, with many fossils, chiefly in casts.
Soft weathered Rag, with many fossils, particularly *Exogyra sinuata*.
Hard Rag.

Amongst the fossils collected by MR. ETHERIDGE, MR. MACKESON, and myself from the phosphate bed are the following:—

Arca.
Cytherea (Venus) parva, Sow.
Exogyra conica, Sow.
Mytilus?
Panopæa (Myacites) plicata, Sow.
Pecten quinquecostatus, Sow.
Rhynchonella Gibbsiana, Sow.
Rhynchonella sulcata, Park.
Serpula filiformis, Sow.
Terebratula oblonga, Sow.
T. sella, Sow.
Trigonia alæformis, Park.
T. ornata, D'Orb.
Wood.

This junction very much resembles that of the Gault and Lower Greensand save in its fossil contents. The latter, when fossiliferous, always has Ammonites, which are here totally absent.

For some miles west of Ashford the Sandgate Beds retain the same general character as to the east, but they lessen gradually in thickness. They are probably about 30 feet thick near Lenham, thinning still more westwards. At Maidstone they are about 14 feet thick; further east they become too thin to be separately mapped, and are then included in the Folkestone Beds.

* These beds are well shown in the cuttings of the new railway from Saltwood to Seabrook.

Fuller's-earth has been dug N.E. of Vintners, near Maidstone; these workings may be those described by WOODWARD,* who mentions shells as occurring in the fuller's earth "generally much "rotten and decay'd." Shells also occurred above the fuller's earth in "a stratum of loam, abounding with sand," probably Folkestone Beds.

In an old quarry at the *Up* of *Upper Preston*, south of Aylesford, the Sandgate Beds are very thin and rest on rag with mollusc borings. The Sandgate Beds are a sandy clay with fuller's-earth, 2 or 3 feet thick, and pass upwards into the sand of the Folkestone Beds. At the base of the Sandgate Beds there are shells, in fragments, with some small pebbles of quartz and sandstone. Below this is a thin bed of hard rag, 2 inches thick, with mollusc borings,† then an inch or two of sandy clay with shells and below that the ordinary beds of rag and hassock.

Some very curious sections of re-arranged Sandgate Beds were seen in a cutting of the Maidstone and Sevenoaks Railway on the north side of East Malling Woods and ⅓ of a mile south of the 3rd milestone from Maidstone. The section showed fuller's-earth and sand (apparently of the Folkestone Beds) with flints and pebbles in the lower part, 8 or 10 feet in all. This was apparently a wash from the higher ground on the south, where Sandgate and Folkestone Beds occur in place. The boundary lines of this outlier are very doubtful, as the beds appear to be let irregularly into the rag by "pipes," as will be described when speaking of the Medway gravels (p. 179).

West of West Malling the Sandgate Beds are not mapped, and only occasional traces of them are seen. About Sevenoaks they consist of greenish clayey sand, with some fuller's-earth; perhaps six feet thick. Near Westerham and Limpsfield a foot or two of clayey sand is seen in places. At Tandridge, and from thence westwards, they can again be shown on the map; hereabouts there are 10 feet or more of fuller's earth, which is dug in some places.

The typical district of the fuller's earth beds is near Nutfield. Here, however, the beds do not resemble the Sandgate Beds of the coast, a circumstance which has led to some doubt as to their exact position in the series. There can, however, scarcely be any doubt that they are upon the same horizon as the fuller's earth of Maidstone, and this has been traced eastwards into the typical Sandgate Beds of East Kent.‡

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* An Attempt towards a Natural History of the Fossils of England, vol. i. p. 4 (1729).

† This section has been described by MR. BENSTED, who considers the borings to be of comparatively recent date, and all the beds above them to be drift. See *Geologist*, vol. v. p. 450.

‡ In MR. DREW'S MS. I find the following note: "In this neighbourhood [Nutfield, &c.] all the sandstones that have fuller's earth between them, in fact all the beds between the highest and lowest bands of fuller's earth, have been mapped with the Sandgate Beds. I do not mean to say that the beds which at different parts have been mapped as Sandgate Beds are exact equivalents of one another; but I have included the sandstone in order to show the outcrop of the somewhat important series of stone and fuller's earth."

DR. FITTON regarded the fuller's earth as the top of the Hythe Beds*; MR. MEYER as "near the base of the Folkestone beds, and almost on or level with the Bargate stone of Godalming."

Near Bletchingley the fuller's earth exists without important bands of stone, but a little to the west of this beds of hard stone appear between the bands of fuller's earth, as will be seen by the following sections. These are only a few selected from a number. Others have been published by FITTON and MANTELL.†

In the library of the Geological Society of London there is a description in MS. of the fuller's earth pits, by MESSRS. GREENOUGH, R. PHILLIPS, and HORNER," which I believe has not yet been published. The note, which is not dated, is illustrated by sketches. The text is as follows:—

"*Account of the Fuller's-earth Pits at Nutfield, near Ryegate, in Surrey.*

"The fuller's-earth pits are situated within a ¼ of a mile of the village of Nutfield.

"The whole mass appears to dip about one in seven to the N.

Section (? At Bletchingley).

Sandstone, the upper part very friable, the lower more compact, resting on Fuller's-earth.

"The sandstone contains large rounded masses of a fine blue limestone—two of these rows in each stratum. The limestone contains large fossil remains. The sandstone strata are divided by a thin seam of very poor fuller's earth. The upper stratum of fuller's earth is red, passing into white, bad in quality; under this lies the blue, the best of commerce; and under that a poor stratum of yellow. The whole rests upon a coarse dark sandstone."

Section of Fuller's-earth Pits at Nutfield.

	Ft.	In.
A. Soil - - -	1	0
B. Lower Mulatto-stone, with Bastard Caps - -	4	6
C. Cool - - -	3	0
D. Mulatto-stone, with cap-stones ["an argillaceous rock with greenish specks"] - -	7	0
E. Quoin stone - -	3	0
F. Fuller's earth - 10 ft. to	12	0
G. Sand - - -	0	4
H. Hard Rock - -		

Cool.—"Called also the rubbish of the fuller's earth, from its being in smaller pieces."

Quoin Stone.—"Of the same nature with the other rock-masses, but containing no cap-stones and less indurated than they, but more so than the rock lying upon it. It is used for building."

Cap-stones.—"Rounded masses imbedded in the rock, and much more indurated than the rock itself, though apparently of the same nature with it, sometimes, however, differing in colour."

Bastard-caps.—"The same as the above, but not so much indurated."

"The fuller's earth is considered of a very fine quality. Inclosed in the fuller's earth we found masses of crystallized sulphate of

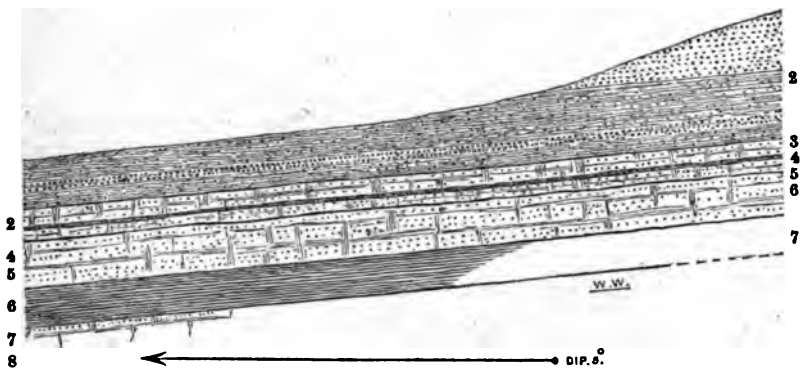
* *Trans. Geol. Soc.*, ser. 2, vol. iv. p. 141. Since writing the above I find that DR. FITTON may have altered his opinion upon this question. In a paper, read in 1844, he says:—"The true place of the Fuller's-earth, at Nutfield itself, is above the Kentish Rag."—*Quart. Journ. Geol. Soc.*, vol. i. p. 181.

† BRAYLEY'S *History of Surrey*, vol. i. p. 146 (1841). A letter from MR. CONSTABLE to DR. MANTELL, *Geol. Mag.*, vol. iii. *See also* WEBSTER, *Trans. Geol. Soc.*, vol. v. p. 353; and MEYER, *Geol. Mag.*, vol. iii. p. 15.

barytes, transparent, and chiefly of a topaz colour. In the Quoinstone are sometimes found Ammonites and some other shells."

The following sketch (Fig. 18) and note is by MR. WHITAKER.

Fig. 18. *Section of the Fuller's-earth Pit, on the Northern Side of the High Road, about a quarter of a mile Westward of Nutfield Church.*



		Ft.
	1. Folkestone Beds. Grey and ironshot sand, with grains of quartz - - - -	15 or more.
Sandgate Beds.	2. Buff sandy clay, with a bed of clayey greensand - - - - -	15?
	3. Soft sandstone - - - -	4
	4. Greenish sandy clay - - - -	½
	5. Sandstone bottom - - - -	2
	6. Sandstone - - - - -	10
	7. Fuller's-earth, the upper part discoloured to a buff tint (by infiltration of water, and consequent peroxidation of iron), the lower part blue. Contains crystals of sulphate of baryta - - - - -	8
	8. Soft sandstone touched below (? belongs to Hythe Beds).	

"The Sandgate Beds here are, therefore, at least 40 feet thick."

In the road going south, just south of this quarry, there is this section:—

	Ft.
Layers of Sandstone, passing into - - - -	-
Slightly clayey sands - - - - - -	-
Coarse sand with small pebbles, sometimes hardened into a conglomerate - - - - -	2 ft. to 3
Greyish sand - - - - - -	6

Below this, in going down the hill to the south, there are greyish and ironshot sands, slightly falsebedded towards the top, sometimes rather clayey. The iron is often in irregular lines, somewhat resembling the Folkstone Beds.

Possibly the two highest beds here seen belong to the Sandgate Beds. The coarse sand with pebbles appears to be the "pebble bed" mentioned by MR. MEYER in the paper already quoted.

The following notes are by MR. DREW:—

Where the word *Pimlico* is engraved on the map there are several pits, one of which gave the following section:—

	Ft.
Sand and sandstone	4
Yellow or drab fuller's earth	2
Sandstone	6
Fuller's earth	1
Sandstone	8
Blue fuller's earth	1
Sandstone	6 or 8
Blue fuller's earth	8

The bottom of the last was not shown. The sandstone is in beds from a foot to three feet thick, and mostly of a yellowish-brown colour, and with green grains: the lowest bed made a wide roof for the excavation of the earth below.

By Colmonger's Farm the beds shown were:—

	Ft.
Sandstone	3
Fuller's earth	2
Sandstone	7
Fuller's earth	3
Sandstone	9
Fuller's earth: a thick bed, the bottom not seen.	

Near Copyhold Farm on the north of the high road a pit gave the following section:—

	Ft.	In.
Sandstone	2	0
Ochreous Shale	0	6
Fuller's earth with some ferruginous matter which makes it useless	5	0
Fuller's earth, of a drab colour	15	0
Hard Sand.		

The sandstone is mostly brown, but in some beds there are masses of a harder and bluish stone, rather calcareous, sometimes shading off into the former, but sometimes forming well marked lenticular masses.

There is fuller's-earth at Redhill station, and in the cutting at the curve south-west of it.

At Redhill Common the following beds are shown by the S. of *Linkfield Street*, where the roads meet:—

		Ft.	In.
	Sandstone with some ironstone at the bottom	5	0
Sandgate Beds.	Fuller's-earth	0	6
	Fuller's-earth mixed with ochre	0	3
	Fuller's-earth	7	6
	Ironstone	0	2
	Sandstone	0	6
	Ironstone	0	2

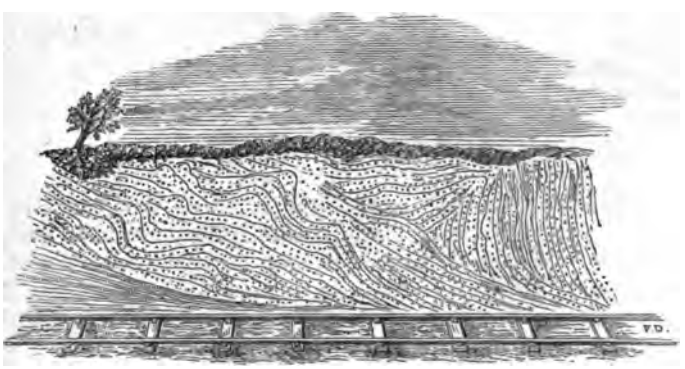
Most likely there are more clayey beds below. There is also fuller's earth in the road south of Reigate Church. West of this the fuller's earth dies out and there appears to be no clay between the Folkestone and Hythe Beds; except at Betchworth Park, where there is some dark clayey sand with pieces of fuller's earth.

From Dorking to Shiere there is no clay between the sand, and in some places the dividing line is very indefinite; indeed from Dorking to Westgate Street (Westcott), the Lower Greensand, with the exception of the Atherfield Clay, is much the same from top to bottom.

The next noteworthy sections are in the railway cuttings near Albury, where, however, there is no clay, the ferruginous sands of the Folkestone Beds being almost at once underlain by Bargate stone, the two separated only by a bed of dark coarse pebbly sand of varying thickness, the grains of which are almost wholly peroxide of iron. This may be the equivalent of the clay in other parts. It occurs also at many other places where the line between the Folkestone and Hythe Beds has been drawn on the map. I believe it to be in some quantity, though there are no good sections, at the edge of Puttenham and Crooksbury Commons, and by Milford Heath, or Witley Common as it is called on the map.*

In one of the cuttings by Albury Heath, just east of the spot where the road crosses the railway, these is a curious section, in which the laminæ of sand, before oblique, have been bent and even contorted. The disturbance seems to have been confined to a bed about ten feet thick, the beds above and below being horizontal.

Fig. 19. *Contorted false-bedding, at Albury Heath.*



In the lane west of St. Martha's (see p. 122) there is apparently a representative of the Sandgate Beds, but from thence westwards to near Witley the Folkestone Beds rest directly on the Bargate Stone of the Hythe Beds.

At the corner of the heath a mile west of Milford House there is some fuller's earth, and there are traces of clay near Wheeler Street.

Near Thursley there is some blue sandy clay, and at Headley there is greenish clayey sand. At this place the beds again thicken, and become of sufficient importance to be mapped. They are seen in the railway-cutting north of Rake, where there may

* "I call particular attention to this bed because it might be of some value as an iron-ore."—(F.D.)

be a total thickness of 50 or 60 feet. The section here is as follows :—

Folkestone Beds -	Buff Sand.
Sandgate Beds -	Buff Sand, with drab clay in patches. Clay, blue, black, green, and drab, with sand. Dark-grained sand (8 feet). Light-coloured sand with ironstone (2 or 3 feet). Clayey sand and clay. Black clayey sand (5 feet). Band of fossiliferous nodules, calcareous and ferruginous (1 foot). Black clayey sand (6 feet). Nodules (as above).
Hythe Beds -	Sand, with crumbly nodules of Bargate Stone (fossiliferous).

At the east end of the cutting some of the beds are less clayey and the ferruginous nodules were not seen.

The railway cutting at Petersfield shows, beneath brown sand of the Folkestone Beds, 2 feet of yellow clay and 12 feet of dark coloured sandy clay with pyrites; still lower, after a gap in which no section is exposed, comes buff sand, clay, and dark-grained sand.

F. Drew.

The sections just noted at Rake and Petersfield show the commencement of conditions which very strongly characterise the Sandgate Beds of Western Sussex. The clay which immediately underlies the sands of the Folkestone Beds continues with scarcely any change to Heath Common, near Ashington. It is also seen at Henfield, beyond which it, and all the other divisions, rapidly lose their distinctive characters.

The higher beds are well seen in the railway cutting north of West Heath, just on the eastern edge of Sheet 9. The Folkestone beds here are white and buff sand, falsebedded, with very little ironstone; but at the bottom, resting on the clay below, is a layer, from 1 to 6 inches thick, of coarse-grained iron-sandstone, sometimes changing into a concretionary ironstone. The sands have been much dug away for ballast, and this hard bed forms the floor of the excavation.

The ironstone rests directly on dark clay with very little sand in it, not very unlike gault; for about 10 feet down it continues the same, and then gets rather sandy until at about 15 feet it is a hardish bed of dark ferruginous sand, somewhat clayey in places. This weathers, when dry, into a yellowish iron-sandstone. At the bottom of the cutting, towards the eastern end, sands come out from under the iron-sandstone. They are buff and grey, loose and false-bedded. Springs are thrown out through this district by the clay. The clay is seen in many places east of this, particularly along the north side of Trotton Common.

A great part of the middle and lower part of the Sandgate Beds is, in this part, composed of sand which is generally finer in grain than that of the Folkestone Beds. This sand renders the junction with the Hythe Beds very uncertain in many places.

The dark-grained sand seen in the cutting at Petersfield is very peculiar. It occurs towards the lower part of the Sandgate Beds for some miles to the east, and may be well seen in the railway cuttings south and south-west of Sellham. It appears to be made up in great part of grains of ironstone.* It occurs over the northern part of Cowdry Park, and can be seen along the road to Halfway Bridge; sometimes, as in the railway cutting just noticed, it consists chiefly of iron grains, sometimes with these grains disseminated through a lighter sand.

Excellent sections of the buff and yellow sand are seen on the south of Midhurst, and in the lanes near Coster's Mill. The railway-cutting south-east of the mill shows the clayey beds at the top of the division.

In the railway-cutting east and west of Petworth Station the beds are well shown. On the east side of the station, there is:—

	Ft.	In.
Clayey sand, passing into		
Dark shaly clay - - - - -	about 10	0
Ironstone beds - - - - -	6 in. to 0	10
Bright yellow sand, like Folkestone Beds, but more evenly bedded than they - - - - - -	10	0

In the cutting west of the station yellow sand occurs on the top. This appears to be the same as that to the east, and of which there must therefore be a considerable thickness.

The section here is:—

	Ft.	In.
Yellow Sand passing below into		
Sand with hard ferruginous beds, together in thickness nearly	40	0
Dark clay - - - - - - -	10	0
Sand, buff and grey - - - - - - -	20	0

Were it not for the clay seen east of the station one might be inclined to include the yellow sands in the Folkestone Beds,† but the general section is very like that now to be described, save in the greater thickness of the yellow sand.

The Sandgate Beds are very well shown in the neighbourhood of Pulborough, where the order was ascertained by MR. GOULD to be:—

	Ft.	In.
(1.) Shale and clay - - - - - - -	30	0
Thin parting of iron-grit.		
(2.) Yellow sand, sometimes hardening into a soft sandstone	18	0
passing into		
(3.) Sandy clay and clayey sand, containing 4 or 5 layers of fossiliferous ironstone nodules. It varies in thickness from - - - - - - 12 ft. to	20	0
(4.) Clayey sand - - - - - - about	40	0
Gradually passing into the Hythe Beds.		

The shale (1) with the underlying sand and its ferruginous crust is cut through in the road south of Pulborough Church, and in the road at Codmoor Hill, see fig. 20, by MR. GOULD.

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* See the description of similar sand at Albury, p. 134.

† DR. FITTON regarded the clay at Pulborough as a subordinate clay of the upper division, Folkestone Beds, and compared it with a clay near Reigate (*see* p. 141), *Trans. Geol. Soc.*, vol. iv. pp. 142 (note), 155.

Fig. 20. Road Section, at Codmoor Hill.

The fossiliferous nodules are very well seen in the railway-cutting west of the church and in the lane north of Park Farm, where they are imbedded in a fine sand, sometimes somewhat clayey. The nodules are very fossiliferous, one was 12 inches in diameter. Higher up the lane, to the south, there is the yellow sand and sandstone capped by its hard grit, and still higher the stiff clay and shale.

I obtained from these nodules the following fossils, named by MR. ETHERIDGE:—

Rhynchonella Gibbsiana, Sow.	*Rostellaria.*
Cyprina angulata (?), Flemg.	*Thetis Sowerbyii*, Röm.
Inoceramus.	*Trigonia alæformis*, Park.

To the west of Pulborough the nodules disappear; they are absent at Codmoor Hill, and still further west this part of the Sandgate Beds appears to change into the iron-sand already described. Fossiliferous nodules, however, were found in a well at Midhurst, and, possibly, those at Rake (see p. 135) may represent them.

The fossils found by DR. FITTON at Parham Park * were obtained from these nodules. The Sandgate Beds are there brought up by the Greenhurst anticlinal. The section there shows 12 or 14 feet of clayey sand with rows of nodules. They are also exposed on the north of Chiltington Common. From all these localities fossils might be collected.

The shale and clay at the top of the division continues east from Pulborough, and may be traced by Home Street, Mare Hill, and round the Greenhurst anticlinal to Storrington and Heath Common.

At Henfield the beds also appear, and are seen in the old lane leading south from the mill. Here there is dark clayey sand divided by yellow sand.

In the road west of Hassock's Gate Station there is this section:—

		Ft.
Folkestone Beds -	Red sand with ferruginous grit.	
Sandgate Beds	Dark chloritic sand with some clay - -	10
	Grey chloritic sand - - - -	4
	Dark clayey sand - - - -	10
	Parting of ferruginous grit.	
	Coarse sand with more clayey sand below, gradually passing into the Hythe Beds.	

* *Trans. Geol. Soc.*, ser. 2, vol. iv. pp. 157–159. *See* the section described, and lists of fossils given in MANTELL'S Fossils of the S. Downs, p. 71. A list of fossils from Parham is given in Table III. of Appendix I., pp. 458–468.

FOLKESTONE BEDS.—These are well seen in the cliffs east and west of Folkestone, where they consist of light-coloured sands, sometimes very coarse, enclosing layers of siliceous limestone (Folkestone Stone) and chert; the latter frequently following the lines of false bedding. This division has been very minutely described by DR. FITTON, and carefully measured sections of the cliffs are given in his memoir. The thickness is about 90 feet.

The phosphatic bed (see Gault, p. 147) appears to lie always above the sand, where complete sections are obtained. But nodules are frequently found loose in the sands or in hard concretionary masses on the blocks of stone. Associated with these nodules, and likewise in a phosphatic state, are the following*:—

Ammonites Beudantii, Brong.
A. mammilaris, Schloth.
**Exogyra conica*, Sow.
Inoceramus Salamoni, D'Orb.
**Natica Gaultina*, D'Orb.
Nucula pectinata, Sow.
**Pecten orbicularis*, Sow.
**P. quinquecostatus*, Sow.
**Rostellaria*.

The ammonites are very often found loose in the sands, but only, as far as I am aware, in the highest part within 3 or 4 feet of the Gault. The beds of stone are sometimes sharply marked off from the sands, but often they pass insensibly into each other. The stone resembles coarse varieties of Kentish Rag, it occurs in hard lenticular masses of one or two feet in thickness, often enclosing many small pebbles, which are perhaps more frequently found loosely scattered in the sands.

The Folkestone Beds are comparatively unfossiliferous. The fossils found near the top are nearly always in fragments.

The following is a short list of fossils collected by MR. ETHERIDGE and myself from the higher beds at Copt Point:—

Arca Raulini, Leym.
**Lima* (? *L. parallela*).
Lucina arduanensis, D'Orb.
**Ostrea frons*, Park.
Panopæa plicata, Sow.
Pecten interstriatus, Leym.
Terebratula sella, Sow.
Thetis Sowerbyii, Röm.
An Echinoderm (? *Holaster*).

At about 50 or 60 feet below the Gault is a bed of stone in which large specimens of *Exogyra sinuata* are common; they may be seen in great abundance in weathered blocks on the shore west of Folkestone. Below this horizon the beds are almost devoid of stone, and consist of sand sometimes somewhat clayey. Water is often found in wells on piercing this stone. In the lowest part of the Folkestone Beds an interesting set of fossils may be collected at low water spring tides.† They occur in dark, loose, somewhat clayey sand:—

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* The names of the fossils marked *, on this and the next page, have been kindly supplied us by MR. F. G. H. PRICE.

† This bed may be seen for a short time at the lowest tides a little east of the harbour. MR. PRICE considers that these strata belong to the Sandgate Beds. I also now think this is very likely to be the case, and have so arranged the fossils in Appendix I.

Ammonites Deshayesii, Leym.
**Astarte*.
Corbula elegans, Sow.
**Crassatella*.
**Cucullæa glabra*, Park.
**Dentalium*.
Gervillia anceps, Desh.
Ichthyosaurus campylodon, Carter.
Lucina Dupiniana, D'Orb.
* *Panopæa plicata*, Sow.
Rhynchonella depressa, Sow.
R. sulcata, Park.
Thetis Sowerbyii, Röm. (young forms).
Wood bored by *Pholas?*

The Icthyosaurus bones occur loose in the sand, most of the others in dark coloured ferruginous masses.

The Folkestone Beds rise gradually in the cliff going west of Folkestone exposing the Sandgate Beds below. Most of the base of the clift between Folkestone and Sandgate is occupied by a small undercliff formed by the slipping of the sands above the more clayey Sandgate beds. Springs frequently occur at the junction. The sands continue to form the top of the clift and adjacent plain as far west as Sine Farm N.W. of Hythe, beyond this they recede inland and strike across the country parallel with the Chalk escarpment. There is a small outlier just north of Pedling Green.

For a few miles to the west the composition of the beds is much like that at Folkestone. A section is seen in the railway cuttings by Cheriton, where the cherty beds distinctly mark false bedding. The false bedding in the Folkestone beds has been carefully investigated by MR. SORBY. He finds the mean direction in the neighbourhood of Folkestone to be N. 25° W. indicating a current *from* the N.N.W., with open sea to the north; the oscillations produced by tidal currents MR. SORBY considers to be small in this district.*

"To the west of Saltwood the beds change in character. The stone disappears, as also for the most part does the chert, and they become simply false-bedded sands with occasionally irregular lines of ironstone: this character the beds retain for many miles to the west.

"There are sections opened in various places but none of any particular interest. The sand is much dug for building purposes.

"In the road going N. from Willesborough Lees to Blackwall Farm, and but little below the junction with the Gault, some thin seams of clay are seen in the sand, with false-bedded sand below. Good sections are seen at Potter's Corner and again at Hothfield Common. Just south of the *W.* of *Woolpack* (on Hothfield Common) clay is seen in the lines of false bedding, and in a pit on the east side of Charing Heath, *ironstone* occurs in a similar way.

"At West Harrietsham the sand contains a bed of black or blue sandy clay a few feet thick. Sections of the sand are opened in many places, but none are particularly worthy of notice; that near Berstead, where 'Tumulus' is marked on the map, is a very fine one.

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* *Ed. New. Phil. Journ.*, vol. vii. p. 233 (1858).

"One section may perhaps be given, taken from a pit ¼ mile N.W. of Sandlin, near Maidstone:—

	Ft.	In.
Fine sharp sand, nearly white - - -	18	0
Coarser sand, streaked with brown - -	21	0
Grey clayey sand - - - -	4	0
Fine grey sand - - - - -	6	0
Ferruginous sandstone - - -	1	0
Grey and brown sand - - - -	13	0
	63	0

"At Ightham, near the Roman Camp, is a bed of fine hard white sandstone, 5 feet thick, a good deal like the 'Greywether Sandstone' of the Tertiaries; and there too is another kind of stone, not observed elsewhere, a hard and tough dark green sandstone or rather grit. This was not seen in place, but on Ightham Common it is found in large masses and is there called 'Ightham Stone' and sometimes 'Firestone' from its being sufficiently hard to strike fire well."

In the railway cutting at the Royal Oak there is a great deal of the dark iron-sandstone. One bed is 5 feet thick in places but is not continuous as a hard bed, changing into soft sand and then hardening again.

The thickness of the Folkestone Beds appears to vary very little throughout the whole of the district already described. On the coast they are 90 or 100 feet thick, and in a well at Snodland, which commenced in the Gault and passed through the whole thickness of the sands, they were 100 feet.

A curious section in Folkestone Beds is seen by the road side going north from Seal towards Otford Mount. There is false-bedded sand containing small pieces of stuff greatly resembling chalk. These occur beneath a hard black ferruginous band, such as are common in these beds, and which are probably due to infiltration. In one place the chalky matter is clearly overlain by sand, with thin seams of greyish and reddish clay, somewhat like Sandgate Beds. The point at which the section occurs is about 40 or 50 yards from the Gault junction.

These appearances are certainly exceptional. The chalky matter seemed to be truly in the Lower Greensand, and if so might be compared with similar stuff in the Wealden conglomerates at Lindfield (see p. 84). But small sections of this kind are frequently deceiving, and the whole might be Folkestone beds rearranged.*

A good instance of the occasional rapid weathering of ferruginous sand was observed near Seal Church in December 1864. A field on Folkestone Beds here, very red in colour, had been ploughed, but the top of each ridge had entirely lost its red colour, and had weathered almost white. Close below the surface

* Good illustrations of the deceptive appearance of such re-arranged material will be found at pp. 130 and 193 of this Memoir.

the red colour was still unchanged. The weather for some little time previous to this had been fairly dry, but with a good deal of frost.

"In the railway-cutting about a mile east of Reigate there is white sand, 30 feet thick, which is worked for glass-making; and the like also occurs near Frenches.

"In a road-cutting a little east of Wray Common, and in the cutting by the road-tunnel at Reigate, there is some bright rose-coloured sand. Near the top of the sands at the road cutting last named is a clayey bed, or a dark green sand mixed with clay, eight feet thick. It extends some way to the west, and may be seen on the roads leading northwards from Reigate Heath.

"At Reigate and Dorking some of the sand is more coherent than usual, so that it may be dug out in caves with no timbering to support the roof."

The cutting in the Horsham and Dorking railway gives a fine section of these beds. At first sight they appear to be lying flat, with occasional lines of false-bedding dipping N. These, however, are true bedding (dip 20° N.), and the dip has brought the lines of false-bedding into a nearly horizontal position. The bedding (true and false) is marked by thin layers of pinkish clay and clayey sand. The beds are crossed by coloured lines of infiltration and by irregularly branching lines of iron-sandstone.

"There are numerous sections of these sands along their outcrop westwards, but none of great importance. At St. Martha's the thickness seems to be about 160 feet, and in this part the iron-sandstone* is in thick masses."

The high grounds at Albury, Farley, and Black Heaths are occupied by Folkestone Beds. These are on the south side of the easterly prolongation of the Pease Marsh anticlinal.

"At St. Catherine's Hill, Guildford, a good section by the road-side shows some curious waved bands of iron-sandstone. Close by are two other sections of sand, in the railway-cutting and by the river-side.

"On the south of the Hog's Back from Guildford to Farnham there are many sections, in road cuttings and sand pits, but showing nothing unusual; there is always sand, frequently much false-bedded, and with more or less iron-sandstone.

"There are outliers on the high grounds at Farley Heath (S.W. of Bramley), Munstead Heath, and the southern part of Highdown Heath.

"On Crooksbury Common there is much ironstone in the sand; part of the town of Farnham is paved with this rock.

"Some fairly good sections may be seen at Waverley and Moor Park. About half-a-mile east of Bourn, near Farnham, there is a thickness of six feet of coarse dark-grained sand.

"In the neighbourhood of Farnham, the top bed of sand contains nodules of phosphate of lime: like nodules occur in the

* Hereabouts, and to the west, as also in Sussex, this rock is known as "Carstone."

Gault just above, and indeed it is possible that both beds belong to the Gault, but the lowest is certainly in sand.*

"The following good section was seen near Wracklesham Church:—

	Ft.	In.
Blue clay (*Gault*)	5	0
Dark sand with phosphatic nodules thinly scattered through it	3	0
Brown ironstone	0	1½
Dark sand	1	2
Phosphatic nodules with pieces of *Ammonites* and other shells	0	4
Light brown sand	4	6
Phosphatic nodules darker than the last	0	4
Coarse clayey sand with two or three thin bands of clay	5	6
Soft brick-red sand	0	6
Light fawn-coloured sand	10	0

"A boring was made in this village through 120 feet of sand, and then through some coarser earth, which may have been at the bottom of the Folkestone Beds. The thickness here, therefore, is probably somewhat more than 120 feet.

"At the top of the Devil's Jumps ferruginous sandstone is shown, but there are few other sections on Frensham Common."

At Huntingford Bridge a section by the road-side shows:—

Yellowish brown sand, with brown ironstone in very irregular curving forms.
Blue shaly clay, 6 inches.
Sand, 18 inches.
Blue shaly clay, 8 inches.
Very sharp buff and white sand.

About half-a-mile a little west of north of Holywater Clump in Woolmer Forest there is some dark-grained sand mixed with the other, like that before noted (p. 134) as occurring at about the horizon of the Sandgate Beds, and consisting chiefly of peroxide of iron; here, however, it is somewhat above that division.

The upper part of the Folkestone Beds S.W. of Kingsley have already been described by MR. DREW as "loose, brownish-yellow "sand, with much false-bedding, streaked with peroxide of iron, "and containing here and there laminæ of light grey clay."†

At Deal, just on the north-western corner of Sheet 9 there is a large sand-pit, where the sand (white and pure) contains a band of white pipe-clay which throws out water. Resting on this last is sand containing small occasional laminæ of silvery mica. This is close to the top of the sands.‡

At the south corner of Steep Common is the following section:—

		Ft.	In.
Gault	Green sandy clay	2	0
	Green sandy clay, with Phosphatic nodules	1	0
Folkestone Beds.	Brown and green sand, with large pebbles, and at one place Phosphatic nodules at base	2	0
	White sand, with thin laminæ of clay	6	0
	White sand	10	0

* A similar passage at Folkestone is described at p. 147. Sections showing the beds above and below the phosphate band are not at all common; if they were we should probably find this gradual change in many other localities.—W. T.

† *Mem. Geol. Survey*, Sheet 12, p. 4. ‡ From MR. BRISTOW's note book.

The Folkestone Beds of Sussex very much resemble those in the areas already described. MR. GOULD'S notes are as follows:—

"The Lower Greensand at and near its emergence from beneath the Gault, consists of sand which is usually of a white colour, more or less banded or streaked with buff, but is occasionally yellow or even red.

"It forms a barren unproductive soil, and a considerable portion of its outcrop is occupied by wastes and heather-clad common.

"There are, it is true, occasional thin bands of somewhat clayey sand, and in some localities, of pipe-clay. Their amount however is in no instance sufficiently great to materially modify its general unproductive character.

"In this subdivision ferruginous grit occurs in considerable abundance, at times in regular layers, of thicknesses varying from one to three or four inches; at others in disconnected and more irregular masses. The provincial name by which it is recognised is that of *Carstone.* It is largely quarried for use as a road material at Pulborough, Fittleworth, Trotton Common, and other localities.

"The uppermost beds of this subdivision occasionally consist of very pure white sand, most notably so in the neighbourhood of Trotton and Rogate. They usually rise up from below the Gault into considerable eminences, presenting a well marked escarpment towards the Sandgate Beds.

"In this division there are neither limestone nor chert. Its thickness may be 80 or 100 feet."

Fine sections are exhibited in the railway cutting through Midhurst Common. Here there are 40 feet or more of white and buff false-bedded sand with some infiltrated ferruginous bands, but no hard iron-sandstone. In the cutting east of the tunnel, near the *L.* of *Lavington Common* the sand is unusually coarse, and contains many small quartz pebbles. There is some very bright red sand in the cutting further east. There appears to be more *red* sand in the Folkestone beds of this district than in those yet described. It is well seen in the hill near Pulborough, just west of Park Farm.*

In the road-cutting west of Lavington Common there is a good example of false-bedding.

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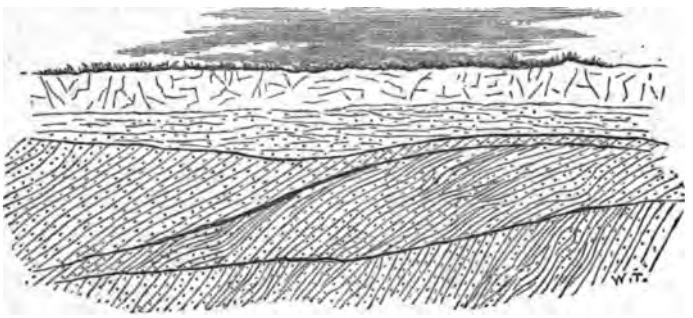
* MR. MARTIN states that the reddest beds of sand contain the largest quantity of "Carstone," *Geology of Western Sussex*, p. 28. MR. MARTIN describes the Folkestone beds under the name of "Ferruginous Sands," which, however, includes the greater part of the Sandgate Beds. The Hythe Beds he call "Lower Greensand," and classes the whole series between the bottom of the Gault and the top of the Weald Clay as "Shanklin Sands."

Fig. 21. *Road Section, west of Lavington Common.*



In the cutting south of Fittleworth there is a very good section, the sand being here extensively dug.* At the top, under the Gault, there is a blood-red ferruginous conglomerate resting on yellowish sand (see p. 150). Some of the sand is pink, not in beds but irregularly shot through the mass. Often there is a hard dark concretionary and irregular mass of ironstone or iron-sandstone in the middle of these pink areas. There is also some white chalky looking substance in veins, running irregularly through the sand. Generally it is soft, but where more sandy and containing coarser white grains it is hard.

About a mile to the west-south-west of this place, and a little east of Red Hill Gate, there is this section:—

	Ft.	In.
Soft yellow sand - - - - - -	1	0
Band of iron-stone - - - - - -	0	2
Sand, greyish for a few inches and then black; it contains a good deal of clay - - - - - -	6	0
Hard white sand - - - - - -	2	0

A little further east there are 30 feet or so of yellow and reddish sand above this.

"A thin bed of chloritic and somewhat clayey sand which is first observed in a pit at Randle's Farm, near Danny (exhibiting a section of the junction of the Gault clay with the Lower Greensand) continues to occur at the very top of the sand for some distance eastwards, and may be seen in the old east and west road north of Lodge Farm, and again just east of Ditchling."†

The Lower Greensand of Sheet 5, most of which is probably the equivalent of the Folkestone Beds, has been already described (p. 126).

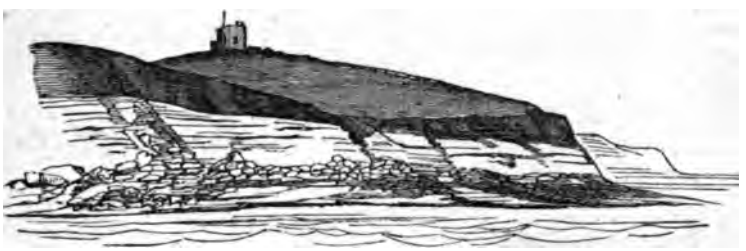
* This section has been described by Mr. Maw, *Geol. Mag.*, vol. vi. p. 335.
† From Mr. Gould's notes.

CHAPTER X.—GAULT.

The Gault is very uniform in character, consisting of a stiff blue clay. It contains a thin stratum of sand at Folkestone, which has not been observed elsewhere. It also contains nodules of phosphate of lime and iron pyrites; and, like most other clays, crystals of selenite after exposure. At Folkestone there are some thin bands of impure clay ironstone.

It may best be studied at Copt Point and East Wear Bay; from whence most of the well-known irridescent fossils are obtained.

*Fig. 22. Copt Point, Folkestone. Gault resting on Lower Greensand.**



Full lists of fossils from the Folkestone Gault have been published by DR. FITTON,† MR. ETHERIDGE,‡ and MR. MACKIE,§ but in these lists the vertical position of each species is not given MR. C. E. DE RANCE has carefully collected fossils from the various "zones," into which it appears the Gault may be divided.‖ He has favoured me with the following section, Fig. 23, and with the lists printed in Appendix I., Table V., in which there are several species new to England.¶

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* Sketch by MR. DREW from Memoir on Sheet 4, p. 10.

† *Trans. Geol. Soc.*, ser. 2, vol. iv. p. 112.

‡ *Mem. Geol. Survey*, Sheet 4, p. 10, 1864.

§ *English's Folkestone Guide*, p. 74 of 1st ed., 1856. Many drawings of Gault Fossils and sketches illustrating the Geology of Folkestone, are given by MR. MACKIE in vol. iii. of the *Geologist* (1860); that at p. 87 well shows the interesting section at Copt Point.

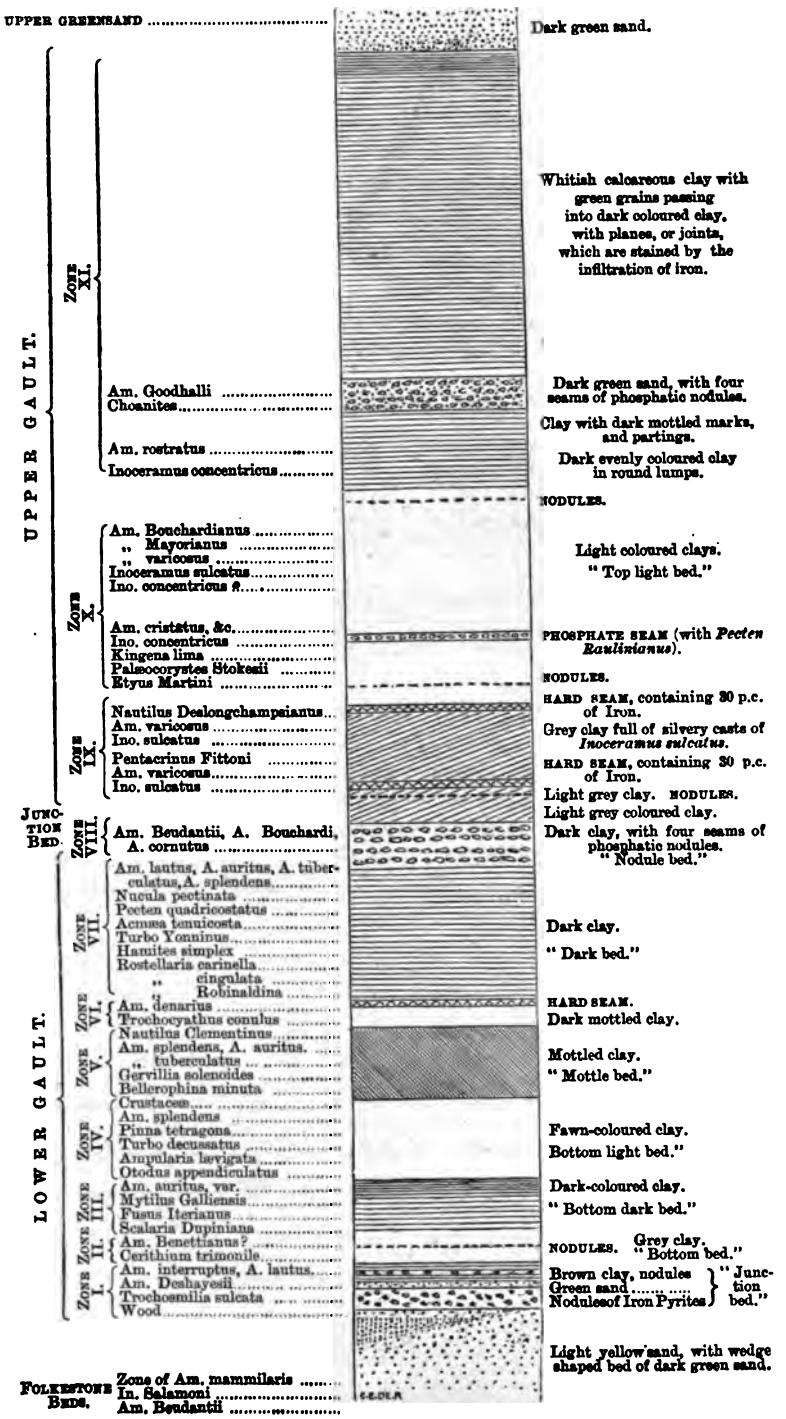
‖ MR. DE RANCE has described the Gault of Folkestone in the *Geol. Mag.*, vol. v. p. 163.

¶ MR. F. G. H. PRICE has carefully studied the Gault at Folkestone; and, in April 1874, he read a paper on this subject before the Geological Society (*Quart. Journ. Geol. Soc.*, vol. xxx., p. 342). The zones into which he divides the Gault are nearly the same as those adopted by MR. DE RANCE; but there are some slight differences, as is pointed out by MR. DE RANCE in his tableof Fossils (p. 434).

Fig. 23. Vertical Section of the Gault at Folkestone.

By C. E. De Rance, F.G.S.

(Scale 15 feet to 1 inch.)



The band of phosphatic nodules at the base of the Gault (No. I. of section) is in a single bed only at Copt Point, but occasionally more than one bed may be observed. At the west end of the Lees, Folkestone, a section (open in 1865) showed three bands of nodules:—

	Ft.	In.
a. Clay, with green grains - - -	2	0
b. Phosphatic band, with bored wood - -	0	6
c. Clayey sand, with green grains - -	1	3
d. Phosphatic band, with bored wood - -	0	1
e. Sand, with fewer green grains - -	1	0
f. Phosphatic band - - - -	0	1
g. Sand, as next above, with a nest of phosphatic nodules in one place.	3	0

In such a section as this the exact junction is not obvious; in fact there appears to be a gradual passage between the true Gault Clay (*a*) and the sand at the bottom, which is no doubt part of the Folkestone Beds.

Phosphatic nodules are seen at the top of the cliff going westwards towards Sandgate, but the Gault Clay itself scarcely at all occurs west of Folkestone Church: the clay in the section noted above being quite a small patch.

The railway cutting half-a-mile N.E. of Cheriton Church also shows the junction:—

	Ft.	In.
a. Sandy clay with phosphatic nodules - -	2	0
b. Yellowish brown sand - - -	2	0
c. Nodules in brown sand - - -	0	6
d. White and buff sand with stone in places, false-bedded - - - -	6	0

The junction bed may be seen in many places near Folkestone, always with the same general character; as, for instance, in a pit near Ford, on the Canterbury road, and in a road section just east of Stone Farm, near Saltwood. The well at the Folkestone Water works, near the Cherry Gardens, was sunk through the Gault to the Lower Greensand; much of the phosphate bed may there be seen lying about.

Sections of the main mass of the Gault are infrequent, and seldom present any facts worthy of notice. A good section is seen at the brick field just south of Folkestone Junction station, and again at Cheriton Tile works. In a pit about one third of a mile north of Stanford Church phosphatic nodules occur in two layers, 18 inches apart. This is some way from the bottom of the Gault, as the clay at this pit is at least 15 feet thick.

There are sections of the phosphate bed near Cheriton, where the nodules are worked for manure (see p. 390).

In a clay pit at Goatly's Lees (two miles N. of Ashford), probably about the middle of the Gault, phosphatic nodules are found. The nodules seem to occur to a certain extent all through the clay, but they are more especially concentrated in a band about a foot thick.

The bottom phosphate bed is well seen at Westwell Leaton (S.S.W. of the letter *L*).

The finest artificial sections of Gault in the district are those of the great brick-pits at Aylesford and Burham. The upper

part, next below the Upper Greensand, is of a light colour. Fossils are very plentiful here, the species being the same as at Folkestone, but they have not here been collected from separate zones. Phosphatic masses with fossils are found *in* the Gault at these pits. The nodules at the junction are very persistent hereabouts; they may be seen in many of the lanes on the west of the Medway.

The thickness of the Gault throughout Kent appears to be generally from 100 to 120 feet. A strange exception to this rule was found at Trottescliffe (Trosley), where in boring for water at the Rectory in 1865–6 the beds appeared to be, unusually thick. The boring was begun a little below the outcrop of the Gault, and, at a depth of 88 feet, a dark loamy silt was met with, 14 or 15 inches thick; this yielded water. Judging from its ordinary thickness this should be near the bottom of the Gault, but on continuing the bore, more clay was met with; this was pierced to a further depth of 94 feet, when the bore-rod broke. The total thickness of Gault then passed through was 183 feet, with the bottom not reached. It may be that the Gault is really of unusual thickness here, or it may be that a reversed fault repeats the beds. Neither of these suppositions, however, is supported by examining the outcrop of the beds, where all appears to be as usual.

Dr. Mitchell notes a well at Wrotham in which the Gault was 120 feet thick.* The same thickness was found at Snodland. These places are respectively two miles west, and four miles east, of Trottescliffe.†

A little north-west of Longford Mill a well was sunk in Gault Clay for 90 feet, and at that depth reached the Lower Greensand. There was no water in the clay, but on reaching the sand, water rose to within 35 feet of the surface. Here, as elsewhere in the Gault, shells were most numerous towards the lower part.

The following notes on Sheet 8 are from Mr. Drew's MS.:—

"West of Battlebridge farm, near Merstham, a well was sunk through 80 feet of Gault, the top 20 feet or so being light blue and brown clay, the rest dark blue.

"In the road-cutting at Stilsum, north of Reigate, the junction with the Lower Greensand may be seen, and there are phosphatic nodules with pieces of *Ammonites*. The like was shown in an opening a little east of Reigate railway-station, and in a road-cutting east of Wray Common.

"Gault is again seen with phosphatic nodules in the railway cutting near Wotton; and again in the cutting north of Abinger Hall, where blue clay is separated by a four-inch layer of brown ironstone from the yellow sand of the Lower Greensand.

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* Quoted by Mr. Prestwich, *Water-Bearing Strata of London*, p. 90.

† Since writing the above I find that in two borings at the Burham Brick pit the Gault was found to be 160 and 200 feet thick. This is so stated in the "Report by the Engineer on the Boring Operations at the Crossness Pumping Station," Metropolitan Board of Works, p. 8, 8vo., 1869.

"Along the narrow outcrop east and west of Guildford there were few sections seen, and none of any depth. There is a good section in the railway-cutting near Badshot, one mile east of Farnham. The junction bed* may be seen on the south of Holt Pound, near Brown's Farm, and in many other places near here. There are many sections on Alder Holt, but they call for no remark, except that in one, about three-quarters of a mile south of Great Lodge, there was a passage from the usual blue clay into clayey sand, though one could not tell how far this extended. In the railway-cutting near Bentley Mill, north of the above, there is stiff blue clay with some brown sand in it. The thickness of the Gault hereabouts appears to be about 100 or 120 feet."

There is some uncertainty as to the thickness of the Gault in parts of Surrey. The narrowed outcrop which it exhibits on the east and west of Guildford may be due to the greater dip of the beds along that line, but it has been supposed that the Gault is really of much less thickness than usual along this line. MR. PRESTWICH remarks:—"at places between Merstham and Guildford it is said to be not more than thirty or forty feet thick, but no distinct measurement has hitherto been practicable."† MR. WHITAKER has observed an interesting section in the road ¼ mile north-west of Gomshall railway station, which seems to afford good evidence of a small thickness of Gault there; his notes are as follows (1873):—

"The section is deep and on the eastern side of the road is much fallen at one place, so as to form a pit-like hollow, in which the junction of the Gault and Lower Greensand is shown, with a dip of 20° or more, northward."

"There are several feet of the 'junction-bed,' consisting of dark grey sandy clay with phosphatic nodules, some of which show a woody structure; this passes down into a clayey greensand, about 3 feet thick, with phosphatic nodules in the upper part; this again passes down into lighter-coloured and more sandy greensand of about the same thickness. Beneath this bed there is nearly a foot of bright-red-mottled sandy clay; then about 2 feet of grey clayey sand, also red-mottled at the bottom; then sharp buff sand.

"Owing to the fallen earth the section is not absolutely continuous, and from the springy nature of the ground is not everywhere easy to get at, but good Gault clay occurs close above, and there are signs of Upper Greensand only about a chain from the junction of the Gault and Lower Greensand, which would give the Gault a thickness of only about 30 feet.

"A very little further up the road the stone of the Upper Greensand is shown, and then, above it, a little pale greenish calcareous sand."

At the south corner of Steep Common there is a section showing phosphatic nodules at the base of the Gault and also in the underlying sand (see p. 142).

* The section near Wracklesham Church has been given on p. 142.
† Water-Bearing Strata, p. 84, 1851.

It is uncertain how far to the west of Petersfield the phosphatic nodules continue. On the south of Midhurst, and for some miles to the east, the junction is of a very different character. The best section is that exposed in the railway-cutting south of Fittleworth.* The junction bed here is a bright red grit, about four inches thick, very hard and heavy, with a great number of quartz pebbles. The same thing may be seen in the road west of Burton Church, south of Petworth Station, and also in many of the streams which cross the outcrop of the Gault; the hard grit often making a small fall in the stream-bed. An excellent section is also seen in the road north-east of Sullington, where the grit is 2 and 3 inches thick. Here the sand below the grit is clayey for a few inches. In these places there appear to be no phosphatic nodules whatever associated with the junction.

In the railway-cutting just west of Elstead Station there is a section of Gault, which appears to be about in the middle of that formation. The clay here contains some hard calcareous nodules, with phosphate of lime. In the road between Burton and Duncton, just opposite the road which goes off to Bound House, there are some nodular masses of clay-ironstone with the concentric structure exceedingly well marked; ironstone is by no means common in the Gault.† Here there are apparently no phosphatic nodules. This section also is about the middle of the Gault.

In East Sussex the phosphatic nodules reappear. They are found in the underlying sand (see p. 127), and also at the actual junction. The following account of a well at Ringmer is given by DR. MANTELL.‡ At the bottom of the Gault he describes "nodular masses of indurated marl, containing an admixture of green sand, with small grains of quartz. These masses are permeated by veins of splendid pyrites, and their external surface is studded with groups of cubo-octoedral crystals of the same substance."

DR. MANTELL describes another well at Norlington Green, Ringmer, in which "at the depth of 20 feet, a layer of red marl, a few inches thick, was discovered, and another occurred 10 ft. lower; this marl is sufficiently soft for marking the paper, and much resembles the red chalk used by artists, but is less pure and of a darker colour; meandering lines filled with a whitish earth, their outline bearing some resemblance to the linear leaves of graminiverous plants, were distributed through the mass. I have observed layers of red marl with precisely similar appearances in a blue marl (or malm as it is there termed) of Bletchingley, in Surrey."

I have not observed any section of the Gault showing this red colour, but MR. MARTIN, in his description of that formation in

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* See p. 144, and the reference there given.

† MR. MARTIN mentions "concretional masses of iron ore" in the Gault of West Sussex; but see note * next page.

‡ *Foss. of South Downs*, p. 83.

West Sussex, says,* it "consists of beds of blue, brown, and sometimes red and yellow clay, passing into a black shale, astringent, and aluminous to the taste." I am not aware of any analysis of the Sussex Gault by which to ascertain the amount and condition of the iron it contains; but the following note by MR. D. FORBES† may perhaps be quoted here. It refers to the middle Gault of Folkestone. "The specimen of Gault is, properly speaking, a marl (not a clay), being a mixture of ferruginous clay with a considerable quantity of carbonate of lime. The iron contained in it is all in the state of protoxide, amounting to 5·96 per cent., which would be equivalent to 6·606 per cent. of sesquioxide (red oxide) of iron, or to 4·62 per cent. metallic iron. The Hunstanton Red Chalk contains more carbonate of lime and much less clay than the above; and all the iron it contains is in the state of sesquioxide (red oxide), which amounts to 5·96 per cent., or is equivalent to 5·28 per cent. of protoxide of iron, or 4·10 metallic iron in the substance; it, consequently, notwithstanding its red, or what generally would be termed ferruginous appearance, in reality does not contain quite as much iron as the Gault does, which has no such aspect. . . . . If the Gault were subjected to any oxidising influences it would assume the red colour of the Hunstanton rocks, as it does also by burning."

Throughout East Sussex the thickness of the Gault is probably about 100 feet along its outcrop, but it appears to be considerably more in the Well at Warren Farm, near Brighton.

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* *Western Sussex*, p. 23. In reading MR. MARTIN'S description of the Gault it should be remembered that he mistook the clays of the Sandgate beds at Pulborough for Gault.

† In REV. T. WILTSHIRE'S paper "On the Red Chalk of Hunstanton," *Quart. Journ. Geol. Soc.*, vol. xxv. p. 191.

CHAPTER XI.—UPPER GREENSAND.

This formation is well seen north of Folkestone, and on the shore at East Wear Bay; but it rapidly thins away inland. Near the flagstaff in East Wear Bay the lowest marly Chalk is seen, overlying, and passing into, greensand, which in like manner overlies the Gault. The upper part of the sand is mostly marly and has fewest green grains; it breaks into peculiar prismatic forms when lying in masses on the shore. This structure is not seen in the bed below, which is more sandy and weathers with a somewhat nodular form, but is all soft alike when broken. The sand here rests somewhat unevenly (or at least apparently so) upon the Gault; passing down into the latter in holes resembling borings, but less regular in shape. A large mass of Greensand stands above the rest, and has stood here, I am told, for at least 20 years. The beds are much disturbed by the slipping of the undercliff, hence the thickness of the Upper Greensand cannot be exactly ascertained. It is probably not less than 20 feet.

Just east of Folkestone Junction station, at the west end of Martello Tunnel, 10 feet of rather clayey and calcareous greensand are exposed in the cutting; there is soft Chalk-Marl above with a few green grains in the lower part. In the heaps of earth above the tunnel-mouth much greensand may be seen, some hard and with nodules.

Below Martello Tower No. 3 the Upper Greensand occurs with a thin capping of Chalk; it may be there 15 feet thick. At the foot of Castle Hill it is exposed in a road-cutting where it is only 3 or 4 feet thick, and contains many small phosphatic nodules.* The Upper Greensand seems to die out to the west of this point. Mr. Simms says it is wanting at the foot of Tolsford Hill, "the only trace of it being some grains of sand mixed with the Chalk-Marl over the Gault." † Still further west (as in the road N. of Stanford) I have not been able to find any, and the green grains seem to be altogether absent, although these may occasionally occur where good sections are obtained.‡

An analysis of the green grains from the Upper Greensand of East Wear Bay gave to Dr. Turner § :—

Silica	48·5
Protoxide of Iron	22·0
Alumina	17·0
Magnesia	3·8
Water	7·0
Potash	trace
	98·3

* The spot where this section occurs in due south of the *C* of *Castle Hill* (Geol. Surv. Map, Sheet 3) in the most easterly of the roads which there branch, and just north of their junction.

† *Proc. Geol. Soc.*, vol. iv. p. 206.

‡ Mr. Whitaker has given me the following note, by Prof. T. McK. Hughes:—"At the base [of the Chalk], immediately above the Gault, there is a thin bed of dark green sand, perhaps the equivalent of the bed containing the phosphatic nodules in Cambridgeshire. This is not exposed in any natural section; but I was informed that it was turned out of some deep drains to the E. of Charing, and was again touched near Eastwell."

§ See Fitton, *Trans. Geol. Soc.*, ser. 2, vol. iv. p. 109.

There appears to be no further exposure of the Upper Greensand until we reach Aylesford, where, at the great brickyard, the following section has been noted by MR. WHITAKER:—

Thin, irregular capping of gravel.
Chalk Marl, whitish, breaking up into small pieces (by weathering); with small dark grains here and there, and also masses of stone; 12 or 15 feet; passing into:—
Greenish-gray marly sand; with dark grains, small irregular-shaped dark nodules (phosphatic), and cream-coloured concretions ("race"). *Upper Greensand.* 18 inches.
Gault Clay; the top three feet or more whitish (at the exposed surface) and marly; the rest dark bluish-grey.

At another spot the Gault is of a dark-grey colour right up to the greensand, and there are phosphatic nodules (the so-called "coprolites") between the two.

At the Burham brick-pit the section is less distinct, but there are here green grains and phosphatic nodules at the top of the clay. The ridge of rock which crosses the bed of the Medway here, visible only at low water, is a sandy calcareous marl with hard nodules and fossils. It was considered by MR. DREW to be the lowest bed of the Chalk Marl, just above the horizon of the Upper Greensand.

Still passing westwards in Sheet 6 the beds appear to keep much the same in character, but they are seldom seen. In the railway-cutting south of Otford there is green marly sand below the Chalk. This was seen again in a field north of Otford, and in some places further west, as near Rye House, Chevening Park, and Brastead Court.

The green sandy bed, which we have hitherto regarded as the only representative of the Upper Greensand, still continues at the top of the formation as we trace it westwards; but near Westerham we find harder beds below which rapidly acquire importance further west, and become there the chief part of the formation.

These beds are known as "firestone" and "malm rock," and there also occur smaller quantities of blue rag and chert. The firestone is a light-coloured calcareous sandstone much used for building. The malm rock much resembles it, but is slightly more chalky looking.

The green sand above the firestone varies much in thickness, but is probably never entirely absent when the lower division occurs. In the Geological Survey Memoir on Sheet 12 this bed was described as "Chloritic Marl" and was classed with the Chalk. This was done, at the suggestion of PROF. EDWARD FORBES, because in Dorset and in the Isle of Wight *Scaphites*, &c. were supposed first to appear in a bed which is considered to be the same as this. As regards the Weald, however, it seems preferable to restore the green sandy marl to its position in the Upper Greensand to which it is generally referred.

Firestone is turned out of the shafts in the "Surrey and Sussex Railway" on the lower slope of the escarpment north-west of Limpsfield. The beds are well seen in some quarries north of

Godstone. Here the workings are carried along underground with the dip, about 4° to the north, the top bed of stone forming an excellent roof. About 6 feet of stone are worked, in beds of from 6 to 12 inches in thickness.*

The total thickness of Upper Greensand near Godstone is, perhaps, about 25 or 30 feet, the lower 20 feet being firestone and the upper 5 or 10 feet soft green sand. Mr. Drew, who mapped this district, included some "marly" beds below the firestone in the Upper Greensand, and thus gave a slightly greater width to its outcrop than it would otherwise have. In this Memoir the greyish "marl" is taken with the Gault.

In a quarry about a mile and a half east of Merstham there is the following section † :—

		Ft.
Chalk Marl	drying hard, with fossils, the lower part sandy and passing into	about 15
Upper Greensand	Greyish-green sand, with nodules of whitish calcareous matter and in parts irregular veins of the same.— Fossils.— The lower part hardened into a soft sandstone	15
	Bed of stone	nearly 2
	Soft greenish-grey sandstone, like that above	5

At Black Bushes, a little east of the last-mentioned spot, the succession is also seen from the Chalk Marl downwards into soft green sandy marl, below which there are two beds of firestone, each 8 or 9 feet thick, and with a bed of hard bluish limestone between them, which is used as road-stone.

Between Merstham and Reigate there are many stone-quarries in which the workings are sometimes carried underground with the dip.

In a quarry near Betchworth Station and a little south-east of Hill Farm, the following section is seen :—

	Ft.
Gravel, made up of flints and pieces of Chalk	3
Soft calcareous sand with much green matter	12
"Hearth-stone"	11
Firestone	12

The firestone is here in beds of about 2 feet thick for the most part. The "Hearth Stone" resembles the firestone but is softer and occurs in thinner beds. It is sold in irregular shaped pieces for rubbing hearths.

The firestone appears to have been worked just east of Dorking Railway Station, where there are some thick beds of stone, but beyond this point, and for some miles to the west, it is not much worked.

Where the fault on the south-east of Guildford crosses the outcrop there is shown, just at the back of the lime-kiln, a bed of green sand with stone below (malm rock) dipping at a high angle.

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* A detailed section of these quarries has been published by Dr. Fitton. *Trans. Geol. Soc.*, ser. 2, vol. iv. p. 137.

† From Mr. Whitaker's notes.

Along the Hog's Back the malm rock can be seen in places, as at Conduit Farm; it is quarried at Shoeland Farm, east of Seale.

About Farnham the malm contains less calcareous matter than in other parts; some of the beds, indeed, do not effervesce with acid, as the malm usually does, but are entirely siliceous; the stone, however, is soft, its grains very fine, and its general appearance not much unlike that of chalk: some of its silica is soluble in caustic potash (*See* p. 390). Some of the softer malm is used hereabouts as a dressing for land.

The greensand is seen in roads on the east of Farnham and north of Berry Court, Bentley.

The following notes on the Upper Greensand of Sheet 12 are extracted from the Memoir on that sheet * :—

"At the base of the Chalk-slope the 'first bed, rarely visible, of the Upper Greensand crops out, and, a little below, the hard rocky beds come to the surface. These occupy a terrace, the small inclination of which nearly corresponds to the dip of the strata, but stretching for a width of a mile and a half or two miles, the summit attains a considerable elevation, and ends in a sudden slope or cliff, so steep that it is impossible to get the ground under cultivation, and it is therefore left covered with wood.† Below the cliff, which may be 40 or 50 feet in depth, the softer beds of the Upper Greensand crop out, underlaid by the Gault, a little lower down. In this part of the hill, however, the regular strata are covered by large masses of malm rock that have fallen from the cliff, and carried the kind of soil characteristic of this formation below the geological boundary given in the Map, which marks where the junction of Upper Greensand and Gault lies underneath the tumbled masses.' ‡

"The whole of this formation comprised in the south-eastern corner of the Map extends from Selbourne on the south to Lower Froyle. In mineral character and appearance it differs considerably from the corresponding formation in Dorsetshire and the south-west of England, in being more calcareous, and of a much whiter colour. The 'malm rock,' in fact, bears so strong resemblance to chalk, especially in the upper part, where it is most calcareous, that it might easily be mistaken on a cursory observation for the lower hard beds of the Chalk itself. . . . . ."

"Plentiful springs are thrown out at the surface of the ground by the upper beds of this formation, and also by the underlying Gault.

"The beds contain *Pectens* and other organic remains common to the formation in other localities, and large *Nautili* are found in the rock at Froyle. Fossils are not, however, of frequent occurrence, and the most ready mode of obtaining them is from the quarrymen, who generally save what they find in breaking up the stone. A fine collection of fossils from the Upper Greensand and

* Written, in this part, by Mr. H. W. Bristow, pp. 4, 5, 9, 11, 12.
† A view of this escarpment, seen from below, is given in Fig. 55, p. 260.
‡ From the Note-book of Mr. Drew.

the other rocks in the neighbourhood of Alton has been made by Mr. William Curtis and deposited by him in the Museum of that town, which is also indebted to his persevering industry and scientific attainments for the greater part of the natural history collections it contains.

"This formation may be conveniently studied in numerous quarries and deep road-cuttings which occur in the area occupied by it, in the south-eastern corner of the Map. This is especially the case in the neighbourhood of Binstead, in the lane from West Worldham to Wilsham, and in the lanes between and near Norton Farm and Selbourne. In the lane from the latter village to Oakwood, it contains a bed of hard ragstone, nine inches thick, and with a dip of 3° or 4° in a directon 40° west of south. Beyond Norton Farm, at the intersection of the lanes, the malm rock makes its appearance in the hollow roadway and water-course, with a bed of hard, cherty, blue ragstone about a foot thick, dipping 20° South of West at an angle of 6°.

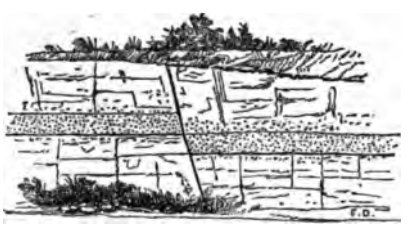
"Between Bonhams and Froyle the telegraph posts and the wooden bridge across the railway are placed upon malm rock."

"The Chloritic Marl,* which occupies a narrow band at the base of the Chalk Marl, makes its appearance between Farrington and Norton Farm, overlying the malm rock, which there dips 6° in a direction 20° S. of W., or nearly coincident with the natural slope of the ground. It consists of a marly sand, with specks of green matter, small rounded pebbles, or rather grains of quartz, and a great abundance of fossilized organic remains dispersed through the mass in a very irregular manner."

"The thickness of this bed is very variable, ranging from a few inches in some places, to as much as ten or even fifteen feet in others.

"The Chloritic Marl is well displayed in a malm-rock quarry, the situation of which is denoted by a small outlier of Chalk about half a mile north-west of Week Green, where it is affected by a small fault which has caused a downthrow of the beds in a northerly direction of about three feet in amount. The thickness of the Chloritic Marl being also there about three feet, the effect of this disturbance has been to bring the upper part of the Chloritic Marl on the north side of the fault to a level with the bottom of the same bed on the other side."

Fig. 24. Sketch in Quarry, half a mile N.W. of Week Green.



* See remarks on p. 153.

"A bed of Greensand, the equivalent probably of the Chloritic Marl, is seen in the lane leading from Alton to West Worldham, and also north-west of Selbourne."*

The whole thickness of the green sand may be seen by the road-side north-west of Barrow Hill. The Chalk Marl in its lowest beds contains a few green grains which increase in numbers below, the beds at the same time becoming sandy, and thus pass into green sand. This is whitish in its upper part but becomes darker below. Still lower it passes as gradually into malm rock. The thickness from good Chalk Marl to good malm rock is 8 or 10 feet, of good green sand about 4 feet.

The best section of the green sand is that exposed in the lane leading from Barrow Hill to East Meon. The banks for some distance on the south side of the lane are formed of this bed, and a good opportunity is afforded of seeing its horizontal variations. Generally, it is a soft, somewhat clayey, greenish sand; but hardening sometimes into an irregularly bedded green sandstone, and elsewhere into a bed somewhat resembling malm rock, but still with green grains. Phosphatic nodules occur, but are not very plentiful. The thickness seen is from 6 to 8 feet.

It is again well seen at the corner of the three lanes south-south-east of Barrow Hill. There are irregular masses of brownish marly sand, which sometimes run into the ordinary greensand as pipe-like markings; sometimes the greensand runs in like manner into the brown sand. The greensand is dark, but cuts with the hammer with a lighter colour.

Probably this sand continues all along the foot of the chalk escarpment to the east, but it is rarely seen. Succeeding this are the beds of malm rock, which form the Upper Greensand plateau. As seen in road-cuttings, and in some small quarries, the higher part of the malm is tolerably well bedded, and contains some hard layers of blue rag; but in descending the face of the escarpment the rag disappears, and the beds become softer and rubbly; still lower, the harder portions occur only in irregular rounded masses, which break up in concentric layers; and at the foot of the escarpment there are frequently some soft, brown, sandy beds, which directly overlie the gault.

The exact junction with the Gault can very rarely be seen. Mr. Gould saw the lower beds well exposed in a drain at Sunwood Farm, Cocking. "The Marl towards the bottom becomes a soft and rather sandy rock with fine shining particles, ultimately passing rather suddenly into a marly clay, grey mottled with red, which changes insensibly during the next 20 feet into Gault."

The following notes are from Mr. Martin's work†:—

The Chalk Marl "passes into the malm, of which there is a thin stratum, succeeded by a bed of green-sand, and that by the

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* For a list of fossils from the Upper Greensand of the Alton District, see Appendix I.

† Geological Memoir on a part of Western Sussex, 1828, p. 19.

more indurated malm rock, which again gradually resolves itself into the gault clay beneath.

"The green-sand, which gave the original name to this formation,* is sometimes disseminated through the whole mass; at others, it exists in distinct beds, which crop out, deprived of their upper coat of malm rock, and form an arable land somewhat more porous than the malm in general, but, being mixed with diluvial earth, and the detritus of the chalk, is scarcely distinguished from the other malm land, and not inferior to it in fertility.

"The best sections of this stratum are to be found at Steyning, Amberly, Bury, and Barlavington. Its relative position is very well exposed in the hollow way leading to the downs at the latter place, and better in the hollow leading from the turnpike-road to the church, at Bury. It is here from fifteen to twenty feet in thickness.

"These beds of green-sand are never found but in the upper part of the malm formation."

In the road south-east of Barlavington Church the green sand hardens into a sandstone such as has already been noted near East Meon, and which, as we shall presently see, forms the larger part of the formation at Eastbourn.

From about Steyning eastwards the Upper Greensand changes its character, the beds get softer, and the terrace less strongly marked. In the cutting north of Clayton Tunnel, on the London and Brighton Railway, there appear to be no hard beds, the formation consisting wholly of darkish sandy marl and marly sand. Again, in the cutting south of Cook's Bridge Station, there are no hard layers; but the beds not far below the chalk are soft, sandy, and rather brownish, with dark markings. They somewhat resemble malm rock which has not become indurated. The lowest beds, seen at the north end of the cutting, are brownish sandy clays becoming darker and more clayey below, the lowest beds exposed being blue and slate-coloured clay, still rather sandy. Perhaps the greater part of this is Gault, the difference in colour being due to different degrees of dryness and weathering.

The Upper Greensand expands near the coast, underlying the south-western part of Bourn Level, and forming the subsoil upon which much of the new town of Eastbourn is built. The village of Eastbourn itself is built on the lower slope of the Chalk escarpment. The slight rise upon which Hornsey Farm is built is Upper Greensand, forming an island which rises out of the alluvium of Bourn Level. Greenish clayey sand is seen close by Hornsey Farm, and a well here, 14 ft. deep, probably gets its water from the Gault. The beds seen here are probably the same as those exposed at the lowest point of the cliff near the Wish Tower, and which also form the foreshore from thence towards Sea Houses.

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* Of which Mr. Martin made two sub-divisions, "Upper Green-sand" and "Malm Rock."

Bluish Gault clay is found at the bottom of Crumble Pond, and also at the marked rise, Anthony Hill, on which Tower 68 is built. The dip from Anthony Hill westwards must be exceedingly small. West of the Sea Houses the harder beds occur, and were well seen (in February 1868) near the *M* of *Mount Pleasant.*

The cliff below and S.W. of the Wish Tower (No. 74) shows the Chalk Marl resting on the Upper Greensand in the following order:—

		Ft.	In.
Chalk Marl	- Bedded, with many fossils in the lower part. It becomes hard below, with green grains and small phosphatic nodules, then passing into :—		
Upper Greensand.	*a.* Greenish sandstone with phosphatic nodules, worm-like markings, and veins of carbonate of lime - - -	3	0
	b. Sandy parting - - - 6 in. to	1	0
	Soft stone and hardened sand - 8 ft. to	10	0
	c. Greenish sandstone; hard and generally dark, but sometimes quite light in colour. Falsebedded in the upper part	10	0
	d. Calcareous clayey sand and sandy clay, greenish and brownish with splintery nodules - - - -		

The lowest bed seen in the cliff extends towards the north-east along the shore and passes downwards into blue Gault clay. South-westwards from the Wish Tower the harder beds form rocks and run out into a prominent ridge immediately below the Signal Station (Beachy Head Ledge). There is a small anticlinal in the cliff here. The total thickness of the Upper Greensand at Eastbourn appears to be about 40 feet. This includes the soft sandy bed overlying the true Gault. It is more sandy than the top Gault elsewhere, and in places, as on the foreshore near the new pier, it contains much green sand.

One of the earliest published geological observations relating to the Wealden district is on the cliff section noted above and on the chalk of Beachy Head, by M. J. A. De Luc the younger, in a note made in 1796, and published by De Luc the elder in 1798.* The Upper Greensand is only briefly noted as "calcareous stone, without flint," containing, "among other shells, many Cornua ammonis." Above this is described grey chalk, then white chalk without flints, and above that still whiter chalk with flints. It is further noted that "Cornua ammonis" are common in the lower beds, and "Echinites" in the higher beds.

Dr. Mantell, in his earlier works on this district, regarded the sandstone, &c. of Eastbourn as Lower Greensand, and supposed the Gault to be absent.† The true relation of the beds here was first ascertained by Sir Charles Lyell.‡

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* *Lettres sur l'Histoire physique de la Terre*, p. 202.

† See Appendix III. under the years 1819, 1822 and 1824.

‡ See Dr. Fitton's paper; *Annals of Philos.*, ser. 2, vol. viii. pp. 67, 458 (1824). See also a description of the cliffs in Dr. Mantell's "South-east of England," p. 162; and Mr. Whitaker "On the Chalk of the Cliffs from Seaford to Eastbourne, Sussex," *Geol. Mag.*, vol. viii. p. 198 (1871).

CHAPTER XII.—GRAVELS.

In describing the superficial deposits, it will be advisable to adopt a different arrangement to that hitherto used. The most natural method will be to treat each river-basin separately, whatever the formation may be which underlies the gravels. These will, however, be noted in passing, and it may be premised that the area most thickly covered by drift is that of the Weald Clay; next to that comes the Gault. As both Weald Clay and Gault form naturally stiff and retentive soils it is particularly important that the distribution of the superficial and more porous beds upon them be well understood.

I must here anticipate one point, which will be more fully considered presently, relating to the original courses of the eastern Wealden rivers. I think there is good reason to believe that originally there were six rivers passing out of the Weald on the north, and probably six, certainly five, on the south. The higher branches of the sixth northern river we now see in the Rother, which is wholly on the north of the central anticlinal line. The higher branches of the fifth southern river we now see in the streams which drain into Pevensey Level. This river we may call the Ashburn, which is the name of the largest stream. The sixth southern river is the Liane, which drains the greater part of the Lower Boulonnais, and falls into the sea at Boulogne.

*Lines of Watershed.**—The anticlinal which has already been described as cut by the coast line at Fairlight (p. 48) is also the main line of watershed. It is prolonged westwards by the high ground of Ore; from thence it descends to the "pass" at Battle, but mounts the hills on the west of that place and traverses the Ashdown Sand area of Brightling and Heathfield. Its line almost precisely coincides with the turnpike road from Ore to Battle, and from thence by the road through High Wood to Netherfield Gun. Here the watershed turns a little south for about a mile, and then again coincides with the road as far as Wood's Corner, near Dallington, where it makes a sudden bend southward for a mile or so by Sapperton Farm, and then back to the main road at Three Cups Corner, where the watershed of the Cuckmere and Ashburn branches off, turning south-south-west. From here it again keeps close to the road to Cross-in-hand. The whole exposure of the Purbeck Beds lies to the north of this line of watershed. From the coast to within a mile of Battle, the watershed very closely coincides with the anticlinal line; west of Battle, however, it is wholly to the south of this line.

Cross-in-hand is one of the chief meeting points of the Wealden Watersheds. From it, passing south-west by Hawkhurst Common to East Hoathly, runs the parting of the Ouse and Cuckmere waters, whilst northwards, by Hadlow and Butcher's Cross, still keeping to the turnpike road, is the continuation of

* These are shown by blue lines on the Map at the end of this Memoir.

the main line we have just been tracing. It continues its northerly direction as far as Castle Hill, Rotherfield, when it again turns west, and passing through Stone Cross mounts the higher ground of Crowborough.

From the coast to Rotherfield all the streams on the north of the line of watershed are tributaries of the Rother, but from Rotherfield westwards they flow into the Medway. The line, west of Crowborough, keeps for some distance within the Ashdown Sand area, by Nutley, Charlwood Gate, and Wytch Cross, to Tyhes Cross. Here it leaves the Ashdown Sand and passing through West Hoathly bends again northwards. Hitherto the line has been wholly in Sheet 5. It now, however, leaves this sheet, and, taking in the extreme south-western corner of Street 6 (at Selsfield Common), attains its extreme northern limit within the Hastings Beds area at Turner's Hill, on the eastern edge of Sheet 8. From here there runs, in a northerly direction, the watershed of the Medway and the Mole. The latter now becomes our northern boundary. From Turner's Hill the central line has a general south-easterly direction over Balcombe Down to Hand Cross. Here it is met by one of the southern lines of watershed; that of the Arun and Ouse. The central line, which from Cross-in-hand has been the northern boundary of the Ouse basin, now, at Hand Cross, becomes the boundary of that of the Arun. The Adur is a river coming between the Arun and the Ouse, but its watershed does not quite reach the central line.

From Hand Cross the central watershed runs in a winding line over the northern part of St. Leonard's Forest and across the Weald Clay flat to Leith Hill. Here it is continued north-west over the Lower Greensand by the watershed of the Wey and Mole; but the central line bends sharply round to the west-south-west, and takes the top of the Lower Greensand escarpment as far as Holmbury Hill, then descends again into the Weald Clay plain. The length of the escarpment thus embraced within the southern basins, is only three miles in a direct line. On reaching the clay flat the line runs at first south-south-east for four miles, then turns westward and keeps near the county boundary (Surrey and Sussex) for another four miles, when, at a point about midway between Rudgwick and Aldfold, it turns again north-west towards the Lower Greensand escarpment, which it ascends at Hascombe. From hence it runs west along the crest of the escarpment and keeps the highest ground by Hindhead and Black Down, and from thence over Woolmer Forest to the Chalk at Nore Hill, Selbourne.

This central line of watershed has been traced thus minutely as its relations to the main lines of elevation are important (see p. 217).

The Brightling line of elevation appears to be lost a few miles west of the place from which it takes its name, and the watershed also retains its east and west direction only as far as Cross-in-hand. The second great line of elevation is that passing through Ashdown Forest; here again coinciding with the watershed. The extremities of these lines are connected by the high

ground which runs north and south by Hadlow and Butcher's Cross.

Over Ashdown Forest the watershed runs rather on the south of the anticlinal line, as it does generally in the Brightling district. On leaving Ashdown Forest the watershed winds about over country in which there is no definite line of disturbance: the beds over St. Leonard's Forest are remarkably flat.

In the foregoing description of the main line of watershed the points of junction with subordinate watersheds are noted. It is not worth while to describe these in detail; the map will show their directions. There are, however, two of the northern rivers (Darent and Stour) which do not approach the central line, concerning each of these and the Rother a few words are necessary.

The Darent is the smallest river within the Weald, and is wholly confined within the Lower Greensand and Gault areas. It is surrounded, except on the north, by the basin of the Medway. The watershed leaves the chalk escarpment at Tatsfield and passes over the curious outlier of Gravel on Bowling Green, near Limpsfield. It then takes the crest of the Lower Greensand escarpment as far as Fork Common, east of Knole Park, where it turns north-east over the Folkestone Beds of Ightham Common, and enters the Chalk just west of Wrotham.

The Stour is mainly a Lower Greensand river, but it includes a small area of Weald Clay. Its western line of watershed leaves the Chalk between Harrietsham and Lenham, and runs nearly straight to the Lower Greensand escarpment at Boughton Malherbe. It keeps near the escarpment as far as Pluckley, where it descends to the Weald Clay and winds about over the outliers of Lower Greensand, passing to the south of Kingsnorth. At Aldington it again takes the Lower Greensand as far as Pedling Green, where it turns northwards and reaches the Chalk at Tolsford Hill.

The basin of the ancient Rother joins that of the Stour from near Kingsnorth to Tolsford Hill. From the latter place eastwards the watershed crosses a broad depression in the Chalk near Etching Hill, and mounts the escarpment on the west of Paddlesworth. From hence eastwards to Folkestone its line is along the crest of the escarpment. From near Kingsnorth (on the Weald Clay) westwards, the basin of the Rother joins that of the Medway. The watershed runs on the north of Woodchurch, past High Halden, and enters the Hastings Beds country on the south of Biddenden. It then ascends to the higher ground and passes through the following points, Godard's Green, Hartley, Bedgebury (between the wood and the park), Flimwell, Ticehurst, Wadhurst, Best Beech Hill, Mark Cross, Argus Hill to Castle Hill, at Rotherfield, the meeting point of the Rother, Medway, and Ouse basins.*

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* Some very interesting topographical notes are given by Mr. M. A. Lower in his papers on "The Rivers of Sussex." *Sussex Arch. Coll.*, vol. xv. p. 148 and vol. xvi. p. 247.

The following table of the rivers draining the Weald is (with a few minor alterations) taken from the Ordnance Survey Map of "Rivers and their Catchment Basins." Of these rivers only the Rother and Ashburn, with the tributaries of the Medway, are wholly within the Weald. The rivers are arranged in the order in which they will be now described.

	Name of River.	Length of principal Stream in Miles.	Total Area of Basin in Square Miles
Northern Rivers.	I. Rother	27	400
	II. Stour	42	373
	III. Medway	44	680
	Tributaries of the Medway: Beult	21	
	Teise	13	
	Eden	13	
	IV. Darent	15	314*
	V. Mole	35	Area not separately estimated, included in the Thames Basin.
	VI. Wey	38	
Southern Rivers.	VII. Arun	37	370
	VIII. Adur	16	160
	IX. Ouse	26	205
	X. Cuckmere	17	75
	XI. Ashburn (Old Haven)	8	121
	(XII. Liane.)		

River Rother.

The small streams which flow into the sea near Hythe and Folkestone were probably originally tributaries of the Rother, before the coast line was cut back into its present form; therefore for convenience of classification we may consider the drift of the Folkestone district in this place.

There are in this neighbourhood no well marked gravels of any extent, such as will be presently described in the valley of the Stour. The drift deposits consist of brickearth, with some few exceptions, and amongst these must first be mentioned the so-called "Bone-bed" at Folkestone Battery. This section was first described by Mr. S. J. Mackie † in 1851. Dr. Falconer ‡ has described the section as he saw it in 1863, and a short note of it, as exposed in 1866, is given by Mr. De Rance.§

Dr. Falconer's section is as follows:—

	Ft.	In.
a. Made earth	6	0
b. Whitish loam (used as Brick Earth)	4 6 to 7	6
c. Marl and Flint Gravel	1	6
d. Lower Greensand	10	8

Bones occurred only in bed *c.*

The following section, exposed close by the battery in digging for the foundation of a house, is taken from Mr. Mackie's paper:—

"Black earth, containing bones of *Canis lupus* and *Sus scrofa*, fragments of ancient pottery and iron arms (?) - - 6 feet.
Calcareous sandy marl.

* This area includes the Cray, the Ravensbourne, and the small streams which run into the mouth of the Thames between Gravesend and Sheerness. In the map I have not included all these in the Darent basin.

† *Quart. Journ. Geol. Soc.*, vol. vii. p. 257. See also descriptions by Mr. Mackie in *Geologist*, vol. iii. pp. 125, 282 (1860), and in *English's Folkestone Guide*, p. 66 of 4th ed. (1865).

‡ *Palæontol. Memoirs*, vol. ii. p. 564 (1868).

§ *Geol. Mag.*, vol. v. p. 165 (1868).

Lower portion of the same with flint and ferruginous sandstone boulders and pebbles, both angular and round.	Marked with wavy lines of stratification, and containing bones of Mammalia.	Bone Bed. 1—5 ft.

Lower Greensand *in situ*."

The following list is compiled from those of DR. FALCONER and MR. MACKIE. The bones collected by MR. MACKIE are now in the Town collection at Folkestone; those referred to by DR. FALCONER are in the Museum of the Geological Society:—

List of Mammalia from Folkestone.

(Those marked × are from DR. FALCONER's list, the remainder are on the authority of MR. MACKIE.*)

× *Bison priscus*, Ow.
Bos primigenius Boj. (× *Bos priscus*?)
B. urus.
× *Cervus tarandus*, Linn.
× *C. euryceros*, Falc. (*C. megaceros*, Hart, *Megaceros Hebernicus*, Ow.)
× *C. elaphus*, Linn.
Elephas primigenius, Blum.
Equus.
× *Hippopotamus major*, Desm.
Hyæna spelæa, Gold.
× *Rhinoceros hæmitæchus*, Falc.
× *Sus.*
Ursus?

This fossiliferous bed is of very small extent, and nothing else at all resembling it is known in the district. It appears to be of fresh-water origin, probably deposited by the stream which now flows into Folkestone harbour 100 feet below.

Capping the East Cliff there are small patches of chalky gravel with flints, Tertiary pebbles and ironstone; probably of sub-aërial origin. A little pebbly gravel, also chalky, is found N. and N.W. of Folkestone Junction station.

A good deal of brickearth is found in this neighbourhood. It covers much of the plain around Inglis Farm, and a good section is exposed north-east of the farm, showing about 20 ft. of loam, with a few flints near the bottom; bones are occasionally found in a "blue earth" just above the sand (Folkestone Beds). The boundaries of this patch are not easily traced. There is also brickearth on the east side of the town, running north of the Junction station, beyond which it becomes mixed with the pebbly gravel noticed above. Around Saltwood Green there is brickearth, apparently of some thickness, but of no great extent.

From the brickearth at and near Folkestone remains of the following mammals have been collected †:—

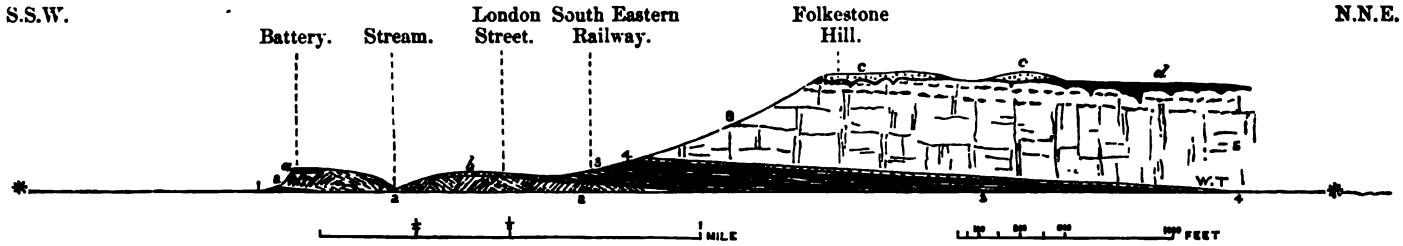
Bos primigenius.
B. urus.
Cervus elaphus.
Equus
Sus scrofa.

"Antlers of deer (*Cervus tarandus*) were found in making the new reservoir of the water-works; and the skulls and bones of wolves are of common occurrence in the superficial soil of this district."

* I omit *Bos longifrons* from MR. MACKIE's list on the authority of MR. DAWKINS. See his paper on "Fossil British Oxen," Part II. *Quart. Journ. Geol. Soc.*, vol. xiii. p. 181.)

† MACKIE. *English's Folkestone Guide*, ed. 1865, p. 67. MR. MACKIE adds *Whale*? This too I omit on the authority of MR. DAWKINS.

Fig. 25. Section through Folkestone Battery and Folkestone Hill.



Horizontal scale 2 inches to a mile. Vertical scale three times as great.

* Level of the sea. *a*. Mammalian gravel. *b*. Brickearth. *c*. Iron-sand. *d*. Clay with flints.
1 and 2. Lower Greensand. 3. Gault. 4. Upper Greensand. 5. Chalk.

[The outcrop of the Gault should have been drawn flatter, and the Chalk escarpment sharper.]

The great number of mammalian forms obtained from the neighbourhood of Folkestone, and particularly from the "bone-bed," is very remarkable. This deposit, of very limited extent, has yielded a larger number of species than all the other superficial beds of the Weald taken together.

Fig. 25 (see last page) shows the relation of the various "drifts" in the neighbourhood of Folkestone.

On the top of the ragstone quarry, just above Hythe Church and on the east side of the road, there are some angular flints, but no regular bed of drift. This place is only two miles from the chalk escarpment.

The gravels of the Rother itself occur in small patches only; there is no continuous sheet remaining along the valley sides, if any ever existed. In no case have any foreign pebbles been found, the gravels being wholly formed of fragments of Wealden sandstone.

The following notes are by Mr. Drew:—

"At the western end of Sheet 4 there is in places some gravelly stuff; sometimes, as near Kennardington Cross, it is cemented together by iron, forming a sort of 'rag-stone.' This often obscures the junction of the Weald Clay and Tunbridge Wells Sand. Probably this is the fragmentary remains of a river gravel.

"By the roadside just north of Blackwall Bridges there is a little gravel, and on the opposite side of the river, west of Gardner's Hill, there is brick-earth.

"At the extremity of the promontory, north-east of Newenden, there is gravel with loam; very little is seen, but a pit is said to have been dug here, eight feet deep, all in gravel. A sandy wash thinly covers a great part of the promontory from Lossingham eastwards.

"At Marsh Quarter, south-east of Sandhurst, there is gravel, some 30 or 40 ft. above the Alluvium.

"Gravel caps the promontory south-east of Bodyham; here too it is about 40 ft. above the Alluvium. A pit showed 7 ft. of small gravel with a few thin seams of sand. There is a little gravel near Abbey Farm and Foulbrook Wood."

The greatest thickness of gravel observed along this valley is at Robertsbridge. A pit, near the bend of the road going east from the village to Redlands, showed 20 to 25 ft. of gravel, entirely composed of Wealden sandstone, interbedded with thin layers of false-bedded sand. Some of the gravel towards the middle is stained black; the thinner pebbles have a brown or black stain quite through them; the thicker pebbles still retain a central core of yellow sandstone. The *bottom* of this pit is at least 30 ft. above the river. Very large quantities of gravel have been dug here.

The railway cuttings from Robertsbridge to Etchingham show loam and gravel; the latter, as usual, of Wealden sandstone only. By the bridge north-east of Bugshill there are 10 ft. of loam and gravel. The cutting near Etchingham has a good deal of loam with 4 feet of stratified gravel in one place. There is

also loam with a little gravel in the cutting north-west of the Church.

The slopes just above the Alluvium higher up the valley have often a good deal of loam. It has been noticed on the north of Frenches, Woodknowl, and Thatcher's Farms.

This seems the most fitting place to notice the elephant remains which were dredged up in 1837 from the bed of the English Channel, between the shoals known as the "Varne" and the "Ridge." It is highly probable that the old Rother ran here, and that these elephant bones may be from its gravel. CAPTAIN J. B. MARTIN* thus describes the bed of the sea:—"The flanks of all these submarine ridges are steep, and there are deep gullies in the intermediate spaces, filled with patches of boulders and blocks of various stones and muddy ground." Some of the masses are Septaria. The bones "are never found on the summits of the banks or shoals, but invariably in deep water in the hollows." In 1835 a bone and tusk were dredged up between Boulogne and Dunge Ness. "The bottom of the channel at the point where it was found consists of blue clay with rounded pebbles." This too would probably be along the course of the Rother.

CAPTAIN MARTIN states that in the Straits of Dover and in the North Sea "the fishermen are . . . occasionally impeded by masses of granite, serpentine, sandstone, slate, and various other stones which are scattered indiscriminately over the bed of the ocean; some of these blocks are much worn and rounded. ." The position of these blocks not being stated, for the Straits of Dover is rather a vague expression, we cannot tell if they occur within the old Rother area.

RIVER STOUR.†

The superficial deposits of the Stour Valley cover a considerable area between Ashford and Wye, larger than those of any other Wealden river when crossing the Gault. At Ashford the Stour divides into two branches, one of which, the eastern branch, rises in the Chalk at Postling; the western branch rises at Lenham.

The gravels of the united rivers will be first described, from the Chalk southwards; then those of the western branch.

The greatest width which the gravels attain, nearly 2½ miles, is just within the escarpment. This great spread is, however, unequally divided. That part east of the river is barely half a

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* *Trans. Geol. Soc.*, ser. 2, vol, vi. p. 161. CAPT. MARTIN speaks of the Varne and Ridge as "Chalk ridges." This is probably a mistake. They are on the south-west of the strike of the Chalk across the Channel, and in the Admiralty Chart the soundings give no Chalk in this direction; *on* the Varne and Ridge there is "sand and shells," *between* them (where the bones occurred) there are "stones."

According to M. THOMÉ DE GAMOND'S researches, the Varne is composed of Portland Stone (Account of the Plans for a New Project of a Submarine Tunnel between England and France . . . 4to. 1870).

† MR. C. E. HAWKINS has recently re-surveyed this district, and has divided the brickearth from the gravel; these deposits will therefore be separately shown in future issues of the Map (Sheet 3).

mile in width, and covers only flat and low-lying ground. On the west the gravels cover a much larger area and rise gradually from the river until, at their western limit, they attain a considerable height. Although the gravel is shown upon the Map (by stippling) as one continuous deposit, it is really cut through by the stream-valleys flowing east-south-east to the Stour; but over the sides of these valleys gravel and loam occur, washed down from above, often in considerable thickness; so that the surface within the stippled area is practically covered by gravel or loam. The north-western extremity of this gravelly area is for the most part obscure, and the termination of the gravel in this direction, as shown on the Map, must be considered as approximate only. This part is also in places covered with a subaërial deposit, containing angular flints, which still further adds to the difficulty of mapping the gravels.

The gravels of this district contain Chalk flints, Tertiary pebbles, fragments of Lower Greensand, and pebbles of sandstone from the Wealden beds. This is the character of the gravels all over the country between Wye and Ashford, and also of those of the western branch of the Stour. The gravels of the eastern branch, from Willesborough eastwards, are characterised by the entire absence of Wealden pebbles. This distinction we shall find to be important when considering the bearing of these gravels upon the denudation of the district.*

The lower gravels are well seen at various points along, or near to, the Ashford and Ramsgate Railway. At Spring Grove the gravel is rather chalky with great quantities of flints; Wealden pebbles, though present, are scarce. Gravel has been largely dug near the railway, by the road from Willesborough to Kennington. At one place there is loam and sand under the gravel, with the sand of the Folkestone Beds below.

The rising ground to the west is in part occupied by brickearth, which is dug in many places. There are several pits north of the word *Wilmington*; one, just south of the three cross-roads, south-west of Spring Grove, showed the brickearth to be a good clean loam, with slight signs of stratification. In some other places in the neighbourhood there are a few flints in the loam. There is also a good deal of brickearth on the south-east of Boughton Corner. Towards Boughton Aluph there is occasionally some gravel, containing apparently little but angular flints; this is probably not of river origin, but it cannot be separated from the adjoining loam. These deposits are of varying thickness, and occasionally, in the midst of a well marked loamy area, the underlying rock appears, as between Broad Street and Perry Court, where Chalk was turned out from just below the surface.

Gravel has been dug in many places over Kennington Common. It contains a very large quantity of Wealden pebbles. Small patches of similar gravel are found beyond the area indicated on

* Mr. Searles V. Wood, jun., has described some of the gravels of the Stour. *Quart. Journ. Geol. Soc.*, vol. xxvii. p. 3 (1871).

the Map. There is some near the park gates by the *o* of *Goatly's Lees*, but Gault clay is found all round about. The gravel of Kennington Common is free from brickearth, containing only some sand in places. To the south-east, about Burton House loam again sets in, overlying the gravel which is found at the bottom of brickearth pits there.

The gravel attains a great height on the north of Sparrow's Hall. The small outlying patches shown on the map have the same composition as the gravels at lower levels; Wealden pebbles are found lying about on the fields.

The high ground about Potter's Corner has traces of gravel, also containing Wealden pebbles. This gravel nowhere completely obscures the underlying sands, and has not been mapped.

Traces of gravel occur about Hothfield, West Street, and Broken Fostal; nowhere of any extent, and only deserving of notice here for containing pebbles of Wealden sandstone. These patches are at considerable heights above the stream, and are doubtless only the remains of old gravel terraces.

At the eastern part of Hothfield Common brickearth is dug to a depth of 8 feet, but from some wells sunk near it would appear to be in places much thicker. At one spot a "black bog" was met with beneath the brickearth.

The low-level gravels from Hothfield eastwards to Ashford are more continuous than those at higher levels, but greatly resemble them in character.

There is one patch of exceptional character in the Weald Clay flat at Dowels Street, 1¼ mile south-east of Pluckley, which is mentioned here only because it comes nearest in position to those we are now describing. It apparently contains *Wealden pebbles only*, and in this respect is unlike all other gravels of this district, but resembles those of the Beult and Teise next to be described. It is close upon the low watershed of the Stour and Medway, and might belong to either valley, though probably it really belongs to the Stour (see p. 188).

On the south-west of Hothfield gravel has been dug on the flat near the river. It is rather clayey and contains many large flints, with some pebbles from the Tertiaries and Wealden. The low-level gravel spreads over the flat ground around Bucksford, and has been dug in places; it always contains Wealden pebbles. At the new (Ashford) Gas Works the gravel is thin and covered by 2 ft. of loam. On the right bank of the stream, north-west of Bucksford Mill, the ground is mostly covered with loam.

The gravel around Ashford is similar in character to that found further north. It has been largely dug on the north side of the town and everywhere contains Wealden pebbles, sometimes in considerable quantity. On the south side of the town, between the Cattle Market and the Railway Station, a deep trench showed brickearth lying irregularly on ragstone, probably in pipes. The gravel at Ashford is a terrace, separated by rock all round from the lower ground near the stream. It is the largest isolated patch of gravel within the valley.

Before leaving the western branch of the Stour it may be well to mention that there are considerable quantities of angular flints over Charing Heath; and to the east of this, in the valley north-west of Swan Street, there is some rather sandy brickearth, 6 ft. or more in thickness. Probably these deposits are both of subaërial origin.

At the foot of the Chalk escarpment near Charing there is a subaërial deposit, which is interesting from having yielded a large number of fossils, some of which have not yet been found in the Chalk itself. The following note was communicated to PROF. T. R. JONES * by MR. HARRIS:—"The village of Charing stands on a bank of 'chalk-detritus,' composed of fragments of white and grey chalk, which gradually decrease in size from blocks of one or two feet in diameter, lying at the top, to very minute fragments, succeeded by still firm particles forming a clay-bed, which, in general, reposes on the chlorite marl (Glauconite). This bank extends from the southern escarpment of the adjacent hills, which form part of the northern boundary of the Weald of Kent, in a gradual descent southward for more than a mile, where a hollow is formed occupying an area of about fifteen acres, and surrounded by chalk-detritus, except at one point, where a rivulet carries off the streams from the chalk-hills. In this hollow beneath the vegetable soil, and also under the banks of detritus, lies the clay-bed above mentioned, varying from one to twelve feet in depth, of a greyish colour and tough consistence, and containing nodules of undecomposed white and grey chalk, and of ochreous and argillaceous substances. This bed abounds with many varieties of Amorphozoa zoophyta, Annelida, Polythalamia, and Entomostraca, with fragments of several species of other Crustacea, and of Echinodermata, and with many specimens of Conchifera, Brachiopoda, and Cephalopoda; also with bones, teeth, and scales of fish. From its general and palæontological characters, this bed would seem to have been formed from the washings of the neighbouring chalk-hills at the time they received their present undulated contour."

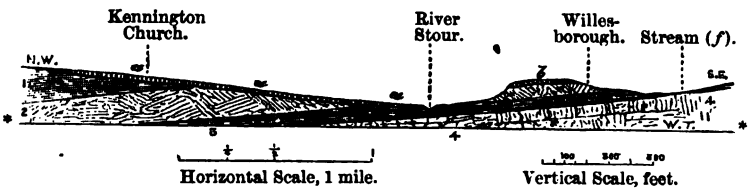
The eastern branch of the Stour appears to have no low-level gravels. There is a little loam on the west of Kingsnorth Pound, overlying Weald Clay, which may, perhaps, have been deposited by this river.

The high gravels are first seen, going eastwards, at Willesborough. There is a small patch within the triangle made by the three roads south of Willesborough Lees, and a much larger patch on the east of this. The southern edge of the former is exposed by the main road, whilst several pits have been opened in the larger outlier just north of Willesborough. In composition this gravel differs from all those before described; there are *no Wealden pebbles*. Neither here, nor in any of the gravels now to be described, have I been able to find them after a most careful

* A Monograph of the Entomostraca of the Cretaceous Formations of England. *Pal. Soc.* for 1849, p. 2.

search; whereas they occur in all sections of river gravel of the western branch, and often in great quantity. Some of the pits north of Willesborough give a thickness of 8 feet of gravel, roughly stratified. The flints are often large and are mixed with Tertiary pebbles and Chert; in some places there is a good deal of sand. Similar gravel occurs further west, near Mersham Hatch and Smeeth.

Fig. 26. Section across the Valley of the Stour.



1. Gault. 2. Folkestone Beds. 3. Sandgate Beds. 4. Hythe Beds.

a. Gravels of the Stour (main river) *with Wealden Pebbles.*
b. Gravels of the stream (f) *without Wealden Pebbles.*

* * Sea Level.

The most interesting patch of gravel in this eastern branch is that at Warren House, one mile north-east of Smeeth. Gravel is dug all over the Common, mostly in shallow pits, but to a depth of 10 ft. in one place. It consists of flints, Tertiary pebbles, and Lower Greensand ironstone, but no pebbles of Wealden sandstone. The flints are very white in colour and rather angular; and there are only rough indications of stratification. Similar gravel caps the opposite hill on the south-east, but here it is more distinctly bedded. These patches are on high ground, and in some respects remind one of the gravel at Limpsfield at the western end of the Darent valley (see p. 193). Unlike it, however, it is well within the river valley.

Brickearth has been dug by the three cross-roads south of Brabourne Lees. It is a clean, good loam, but of no great thickness, and is said to be confined to this spot.

On the north-west of Westonhanger (Hythe) Station there is brickearth which appears to spread over a considerable area towards Stanford. It is dug near the Station, and is there 8 feet thick; a good clean loam without gravel.

The *Alluvium* of the Stour presents few points of interest. Its greatest area is to the north of Kingsnorth; that of the eastern branch is generally of greater width than the western. Between Ashford and Wye the alluvium is generally narrow.

On the east side of the river, near Lavington Farm, there is a good deal of Peat, said, at one place, to be more than 20 ft. thick. It is stated to burn remarkably well.

River Medway.

Drainage Area.—The Medway is the largest of the Wealden rivers.* Its basin completely encloses that of the Darent. It takes in the highest land of the Hastings Beds, of which it drains an area about equal to that of the Rother streams. Of Weald Clay it drains a very large area, larger than that of any other two rivers combined. Of Lower Greensand its area is about equal to that of the Arun, and somewhat less than that of the Wey. In no other Wealden river are the river deposits so extensively developed, and in none are they so important for their bearing upon the question of denudation. For this reason the gravels of the Medway will be described in greater detail than seems requisite for the other valleys.

The Medway itself rises at the western border of Sheet 6, two miles west of East Grinstead. It flows first east and then north-north-east to Penshurst, where it is joined by the Eden which drains the western Weald Clay area. The united streams then flow eastward, past Tunbridge to Yalding, where the Teise and Beult fall in. Then the Medway enters the Lower Greensand and flows north-east to Maidstone, where it turns to the north-west and enters the Chalk just below Snodland.

The gravels are very unequally distributed over the various formations. The Hastings Beds are mostly bare, gravel only occurring in patches along the stream courses. The highest point of the Hastings Beds is Crowborough Beacon, 803 feet; this is within the Medway basin. The whole of the southern part of the basin is high ground, rising to heights of 500 and 600 feet, but falling away gradually northwards with the dip of the beds until, at the line of outcrop—where the sands pass under the Weald Clay—the height is generally from 100 to 150 feet. The highest point along the eastern line is just where the watershed cuts it south of Biddenden, this is 200 feet. The height where crossed by the western watershed is somewhat more, probably about 230 feet.

The highest points attained by the Weald Clay are on the south of Sevenoaks and Brastead, where for about six miles its outcrop very nearly coincides with the 500 feet contour, but by far the larger part of this plain is at a much lower level; that east of the Lower Greensand gorge probably averages about 80 or 90 feet, rising somewhat higher towards the Greensand escarpment. Over this area gravel and loam are very widely spread, occurring both as flats fringing the alluvium, and also as outlying patches capping hills and surrounded on all sides by bare clay slopes. At the western end the gravels of the Eden attain a height of about 300 feet above the sea, and about 80 feet above the adjacent streams. The highest point attained by them north of Tunbridge is 250 feet,

* That is of the Wealden rivers now remaining. I think the ancient Ashburn was at least its equal in size, whilst the ancient Rother, including its tributaries the Slack and the Wimereux, was much larger than the Medway.

or 180 feet above the river at Tunbridge. All the gravels of the eastern branches are much lower than this, but they attain heights of 50 feet or more above their respective streams.

The Lower Greensand area rises, along its western escarpment, to heights exceeding 700 feet at several points. The summit on the south of Brastead is 810 feet. But there is only a narrow strip of country here belonging to the Medway, merely the crest of the escarpment; all north of this drains into the Darent. At the western end of the Darent Basin the Medway passes round it to the Chalk escarpment. Here there are a few points on the Greensand which exceed 500 feet, whilst the summit of the North Down range is here reached. This point, 876 feet, is about ¼ mile E.N.E. of Flint House, 1½ miles N.N.W. of Limpsfield.

The main area of Lower Greensand drained by the Medway is nearly equally divided by the river, but that on the west contains the highest ground; the summit, in Great Comp Woods, being 550 feet. On the western banks of the river gravel covers a good deal of ground, and occurs as scattered pebbles over a much larger area. The highest point attained by the gravel is on the east of East Malling Heath, about 330 feet about the sea, and 300 feet above the river.

The distribution of the material composing these gravels is important. In all the streams of the Hastings Beds area there are only Wealden pebbles, and this is also the case with the gravels of the Beult and Teise, which flow only over Hastings Beds or Weald Clay.* The Eden, however, has flints all along its course, Tertiary pebbles in considerable numbers, and fragments of Lower Greensand. The higher streams feeding this river rise at the foot of the Chalk escarpment, and drain the country around Limpsfield, where there are gravels on the watershed (described with the Darent valley at p. 193) which are composed wholly of flints and Tertiary pebbles. There are also outliers of pebble-gravel on the Chalk escarpment here; all being only the remains of beds which once extended further south. From these sources, and from the Chalk itself, the flints and Tertiary pebbles of the Eden are probably derived. This mixed character pervades the gravels of the Medway all along its course through the Lower Greensand country.

Lower Greensand District.—Just within the Chalk escarpment around Snodland there is a flat of gravel overlying the Gault. Water is obtained all over this district by sinking through the gravel. The gravel does not extend west of the Rookery, but beyond that point the Gault is occasionally covered with angular flints.

A chalky deposit, apparently rain-wash, overlies the gravel in some places near the Chalk.

There is generally a low terrace of gravel along the banks of the Medway as far up as Maidstone. It is not always separable from the higher terraces, but on the south side of the river opposite Aylesford it is quite distinct. The lower terrace rises to

* There are a few exceptions to this general rule which will be pointed out in describing the gravels. (See pp. 186–7.)

about the 25 feet contour, then there is a slope of rock, and above that comes a higher terrace, which, commencing at about the 50 feet contour, passes upwards with a gentle slope, and attains a height of 150 feet at its southern edge.

At Leybourn Wood, north of West Malling, and due east of the word *Sheaf* (*Wheat Sheaf*), there is an outlying patch of gravel. The highest point of the hill is 153 feet. This gravel is separated by a sharp slope on the east side from the lower terrace, which here attains a height of 75 feet.

The height of 150 feet is the summit level of all the intermediate gravels west of the Medway. That at the Rag quarries south-west of Allington Church, about touches the contour at its highest point.

Above this there is a slope of bare rock for 50 feet; and at about the 200 feet contour there come on the higher terraces, which are the most interesting gravels of the district.

The lower gravels are seen in many places near Leybourn; *Elephas primigenius* has been found near the Rectory. A good section is seen at the large sand pit ¾ mile north of Larkfield. The gravel is interstratified with coarse sand, and is stained quite black in some places. The 50 feet contour passes just below the pit. On the south-west of Leybourn there is a deeper section of gravel in the same terrace, and at about the same level. Here 12 feet are seen consisting mainly of flints, with some chert and fragments of decomposed rag. Both here and at the last-mentioned pit Wealden pebbles are extremely scarce, and can only be found by long searching.*

On the right bank of the river, a little north-east of Aylesford Church, is the well known Aylesford Gravel pit. A depth of nearly 20 feet of gravel is here seen, resting on the sands of the Folkestone Beds. It is false-bedded with sand, fine gravel, and loam. Many bones have been found here, chiefly of *Rhinoceros* and *Elephas primigenius*. MR. W. BOYD DAWKINS identifies one of the specimens from this place, now in the Geological Survey Museum, as *Elephas antiquus*, Falc.† This form has been recorded from no other locality within the Weald.

The terrace to which the Aylesford gravel belongs spreads in a continuous sheet from the Burham Gault pits to near Cob Tree. There is again a little gravel by the bend of the river south-east of Allington; and beneath the town of Maidstone the soil is chiefly gravelly, with loam in some places.

At Springfield Paper Mill, opposite Great Buckland, there is gravel slightly raised above the river; it is the northerly end of the spread which underlies Maidstone. This is remarkable for the great numbers of *land shells* which were collected here by PROF. MORRIS, from a loamy sand with pebbles just above the Gravel.‡

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* This fact is important, as, on account of the supposed absence of Wealden pebbles in the gravels outside the Weald, it has been denied that these gravels can have been carried from within the Weald outwards. (See p. 293.)

† "On the Distribution of the British Postglacial Mammals." *Quart. Journ. Geol. oc.*, vol. xxv. p. 195.

‡ *Mag. Nat. Hist.*, vol. ix. p. 593 (1836).

From the railway cutting near Maidstone, where gravel overlies Atherfield Clay, MR. BENSTED obtained a tooth of *Rhinoceros*. This section is now walled up.

The valley near the river above Maidstone appears to be free from gravel till we reach Wateringbury. Here, in August 1864, some large excavations at MR. LENEY'S brewery showed an excellent section of drift. There were 12 to 14 ft. of brickearth, and below that gravel. The gravel rose up sharply as if from disturbance; below this there was clay, its junction with the gravel also rising sharply. I think these appearances were not due to false bedding, but more probably to a disturbance of the beds since the deposition of the gravel. Subsidence, by the dissolving away of underlying beds, can hardly have occurred here, as the great mass of the Weald Clay underlies the gravel.*

Bones occurred in the brickearth but were not preserved. From a gravel pit close by I got some molars of *Elephas primigenius*.

Among the low-level gravel sections of more than usual interest is one by the road just south of the *T* of *Cob Tree*, the description of which I extract from DR. C. LE NEVE FOSTER'S note book:—

"There are two kinds of gravel; a white, chalky, 'pinnocky,' gravel below; and a brown Wealden gravel, sandy in places, above. There is usually a sharp line of demarcation between the two, though in some places they are interstratified.†

"The chalky gravel contains flints, whole and broken, some quite angular, Tertiary pebbles, well rounded pieces of chalk, and some fragments of Lower Greensand chert and siliceous ironstone. There were no Wealden pebbles distinctly in place in this chalky gravel. The thickness seen is 3 ft. in some places.

"Above this chalky gravel there is a deposit of gravel and sand interstratified. The sand is somewhat coarse and is no doubt derived immediately from the Folkestone Beds. The gravel in some places, and especially in one spot just above the chalky gravel, consists principally of Wealden pebbles; but there are also flints, chert, and Tertiary pebbles.

"I believe that the chalky gravel is an old alluvial deposit of the little stream now running a little east of the last *e* of *Cob Tree*, and that this chalky gravel has been covered up by a deposit from the Medway." This spot is less than a mile from the Chalk in a direct line, and very little over a mile along the stream.

On the opposite side of the Medway there is a section in which the chalky pebbles are well interstratified with the ordinary Medway gravel. This is in the railway cutting, just under the bridge, half-a-mile north-west of Allington Church. This appears to be a gravel formed by the main river close by the place where the small stream fell into it. This section is

* Is it possible that the whole isolated mass of ragstone above Nettlested has slipped over the underlying clay and so has caused this disturbance?

† This section has been noticed by PROF. MORRIS, *Mag. Nat. Hist.*, vol. ix. p. 595.

also interesting from the fact that Wealden fossils (*Paludina* and *Cyrena*) are found in some of the fragments. The top of the railway cutting here is betwen 30 and 40 ft. above the river.

The gravel patch on the west of Pennenden Heath is interesting from its height above the river, about 200 ft., and also from its overlooking the valley of the Gault further east. Whatever the origin of this and other gravel patches in the neighbourhood, such as that on the hill-top south-east of Sandlin, it is certain that the Gault valley has been excavated since this gravel was deposited.

The section on next page (Fig. 27) from Maidstone to Deptling will make this clear.

There is gravel about Sandlin, and in many other places in the neighbourhood, where the quantity now remaining is too small to be shown on the map. The character of the gravel is nearly everywhere the same, and in all cases there are Wealden pebbles.

A curious example of disturbed gravel is seen in a pit on the west of Pennenden Heath, about south of the *ge* of *The Grange*.* Here the gravel overlies Folkestone Beds, and at one place gravel and sand dip sharply down to the south-west, whilst in another part of the same pit some small faults are seen. It is probable that the rag beneath the sand has been dissolved away, and that the overlying beds have been let down; much in the same way as the pipes of brickearth have been let down into the ragstone.

A disturbance in the gravel near Preston Hall, on the left bank of the River, has long been known.† Here the gravel and underlying strata are thrown into a sharp anticlinal. "Mr. Bensted considers certain perforations by marine shells in the topmost bed of Rag to be of recent origin. A careful examination, however, will prove, we think, that the bed in which Mr. Bensted has found perforations is overlain by Sandgate Beds and Folkestone Beds; therefore the perforations must belong to the Greensand period. It certainly seems, however, that the gravel has been disturbed since its deposition. May not this be due to a dissolving away of the Rag, producing a subsidence in two places, which has caused the strata to dip down on both sides of the quarry in the manner described by Mr. Bensted?" ‡

The gravel seen west of Barming Heath contains a very large quantity of Wealden pebbles. Around here they seem more numerous than flints and Tertiary pebbles. In the gravel at the Hermitage they are much less frequent.

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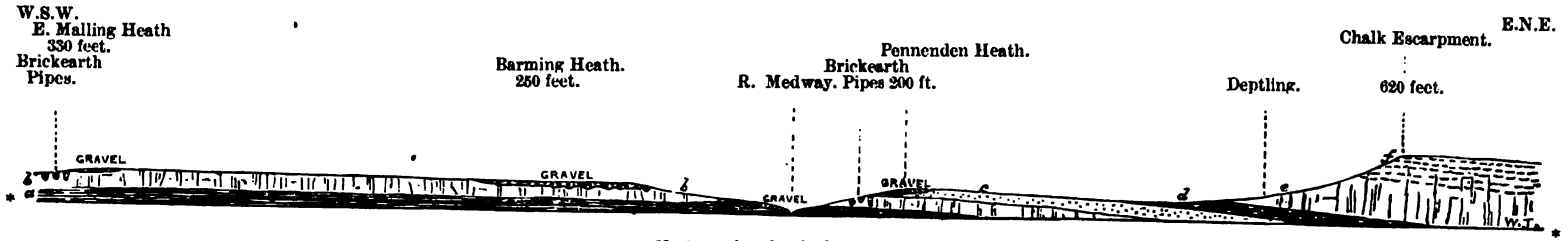
* Figured in *Quart. Journ. Geol. Soc.*, vol. xxi. pp. 458–9.

"By the side of the lane leading from Mount Ararat, in the direction of Postley Fields, the earth sunk some years since in a considerable cavity, supposed to have been undermined by the small streams which break out in a mill pond below."—*Topography of Maidstone and its Environs*, p. 56, 1839.

† Described by Mr. Bensted, *Geologist*, vol. v. p. 450 (1862). See also a note by Sir R. I. Murchison, *Quart. Journ. Geol. Soc.*, vol. vii. p. 383 (*note*).

‡ Foster and Topley, *Quart. Journ. Geol. Soc.*, vol. xxi. p. 459.

Fig. 27. Section from East Malling Heath to the Chalk Escarpment at Deptling.



Horizontal scale 1 inch to 1 mile.

a. Weald and Atherfield Clays. *b.* Hythe Beds. *c* Folkestone Beds.

d. Gault. *e.* Chalk-without-flints. *f.* Chalk-with-flints.

* * Sea Level.

Over a considerable area north and north-west of Barming Heath there are scattered fragments of flint, Wealden sandstone, and Tertiary pebbles; but the gravel seems only to occur in any quantity within the area shown on the map. This scattering of gravel, however, renders the boundary doubtful. The ground over this district is high, being mostly over 250 feet above the sea, or 225 feet above the river.

The highest patch of gravel observed is at a clump of beech trees by the road side east of East Malling Heath and due south of East Malling. It contains flints, Tertiary pebbles, chert, decomposed rag and Wealden pebbles. There are some rather large masses of chert lying about; the dimensions of one of the largest were 12 in. × 8 in. × 9 in.

The road a little west of this point is 328 feet above mean sea-level, or 303 feet above the river at Wateringbury; the gravel pit is at a slightly higher level.

In this pit I got a fragment of flint exceedingly like a "flake," this was lying at the bottom of the pit; but out of the undisturbed gravel I took another fragment that equally resembled a broken flake. Flakes, however, unless they occur in great quantities, are always of doubtful value, as it is not unlikely that natural fractures of flints may occasionally produce such forms. I merely mention this circumstance in case other or more trustworthy evidence of man should hereafter turn up in this district.*

Besides the ordinary river gravel and loam, which has now been sufficiently described, there is, over a good deal of the Gault north of Maidstone, and in part over the Folkestone Beds, a gravel of a different kind which appears to be principally of subaërial origin only. It is largely made up of angular flints and often contains a good deal of *chalk;* sometimes it is mainly composed of chalk or chalky loam. In addition to these characters it is distinguished by the absence of Wealden pebbles. This chalky gravel is locally known as "pinnock." The following notes are from Dr. C. Le Neve Foster's note books:—

"On the eastern part of Pennenden Heath the gravel is intermixed with loam and sand, apparently falsebedded in one place (just south of the *t* of *Pennenden Heath*), but in other places it is wholly unstratified and the materials present little signs of wear. Similar gravel is found by the road to the south, near Callant's Farm. On the north-east of Cob Tree there is chalky gravel with flints.

"There is some difficulty in fixing the origin of these gravels. They may be purely of subaërial origin, or they may have been

* About 1½ miles E.N.E. of this spot, near the Hermitage, I have found great quantities of flakes on the fields; but here, as in numerous other places down the Medway valley, Roman remains occur; and to these, or to a preceding Celtic settlement on the same spot, the flakes belong. The flakes found in the gravel pit differed from them in mineral condition.

Since writing the above, I have shown the flake found lying in the gravel pit to Mr. Franks, Mr. Evans, and Col. Lane Fox, who all, without any doubt, pronounce it to be artificial. I have as little doubt that it originally came from the gravel.

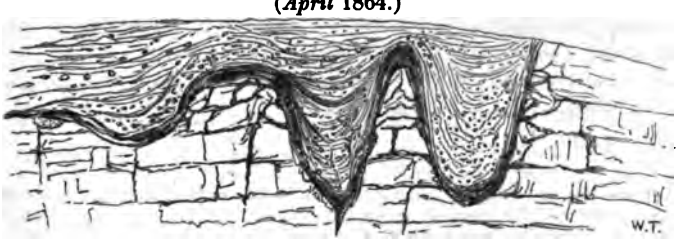
formed by small streams coming down from the Chalk before the Gault valley was formed. But further to the north-west, especially over the Gault near Rowe Place, there is a great deal of 'pinnocky' gravel largely composed of chalk, which is probably all subaërial. In a well at Walnut Tree Farm it was 15 feet deep, with Gault below."

Brickearth Pipes.—Next to the great height above the stream to which the river gravels of the Medway extend, the most interesting circumstance connected with these deposits is the occurrence of long chasms in the ragstone filled with brickearth. These appear to occur all over the Kentish Rag district wherever the gravels extend, *but are never found off the ragstone.* The largest examples are on the north of Maidstone, and here DR. FOSTER and myself first saw them: some are at least 50 feet deep. One is 150 feet across, and extends north and south for a quarter of a mile. For some time the only apparent explanation of them was that they were old stream courses filled up by alluvium. But a careful study of all the appearances satisfied us that this explanation was insufficient, and that they are simply "pipes" of old alluvium let down into the rag by the gradual dissolving away of the limestone.

Probably any geologist who commences his examination of the Maidstone district with these largest "pipes" will at once reject this explanation as absurd; but, on extending his survey to the western bank of the Medway, he will find examples, in nearly every quarry, of pipes from a foot or so in diameter to dimensions almost as great as those above Maidstone. We will commence our description with these smaller pipes on the western bank.

Very good examples are frequently seen in MR. BENSTED'S Iguanodon Quarry;* also in a large quarry near Little Buckland. Generally the pipes are completely lined with the clay and fuller's earth of the Sandgate Beds. Outside that the rag is broken and weathered, showing distinct traces of the dissolving action of water. Inside the clay comes gravel, and in the centre of the pipe, when of any size, there is brickearth. The gravel and brickearth are sometimes intermixed, but more often the latter has clearly been the newer deposit.

Fig. 28. Sketch of small Brickearth Pipes in Ragstone, near Little Buckland. (April 1864.)



* MR. BENSTED has himself described the beds in this quarry. *Proc. Geol. Assoc.*, No. 5, p. 57 (July 1860). The presence of pebbles of Wealden Sandstone in the gravels was first pointed out in this paper.

When the pipes are small the Sandgate Beds generally line them throughout, but in larger examples the beds have often slipped down within the pipe, and then their continuity is generally broken. Slickensides are generally found at these slipped surfaces, which, in small and obscure sections, might easily be mistaken for faults.

The gravel of these pipes always contains Wealden pebbles, and resembles that which occurs at the surface in other places.

At the quarry north-west of Little Buckland some of the pipes may be seen to extend from top to bottom of the workings, a depth of 30 feet; one has been proved 20 feet lower, that is to a depth of 50 feet, without reaching the bottom. At this quarry, and elsewhere west of the Medway, the brickearth is thrown on one side and ragstone only is worked.* The length of the pipes is therefore unknown. They run nearly north and south.

In the tramway leading from this quarry to the South Eastern Railway, seventeen pipes are cut, varying in breadth from 6 to 50 feet.†

Such pipes are sometimes very misleading when exposed in longitudinal section. Along the railway cutting south-west of Allington Church there is a large section of gravel and sand interbedded, eight feet or more in thickness, resting on sand, apparently of the Folkestone Beds, 12 feet thick; the whole looking like a patch of gravel resting on sand. But the rag, where seen, is uneven and comes quite to the surface close by on the north and south, so that this is merely the *side of a pipe.*

On the north-east of Allington Church there are old workings where brickearth has been dug from pipes.

The brick-earth pipes on the northern part of the town of Maidstone are remarkable for their size and for the great value of the brickearth they contain. The custom here is to dig out the loam, leaving the ragstone sides standing; the space is then filled up with rubbish. Much of the ground north and east of the Gaol has been thus worked over.

It is not worth while to describe these pipes in detail; they all present the same features, viz., a central mass of loam with occasional lines of fine gravel, and some "race" or concretionary carbonate of lime. At the sides of the pipe there is sometimes gravel, always containing Wealden pebbles; outside the gravel come some Sandgate Beds, and beyond that irregular fragments of ragstone, weathered, and often plainly waterworn. Often, outside the true Sandgate Beds, intermixed with the weathered ragstone, there is some clay probably derived from the decomposition of the Rag.‡

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* It is perhaps necessary to remark that these observations were made in 1864.

† See a section of this tramway in *Quart. Journ. Geol. Soc.*, vol. xxi. p. 454. The scale there given is incorrect, it should be "1 inch to about 270 feet." The "Capping of River Gravel" is also incorrectly drawn. It does not extend over the pipes, as there shown, but runs into them and caps the ragstone between.

‡ See Prof. T. McK. Hughes, "Note on the Junction of the Thanet Sand and the Chalk, and of the Sandgate Beds and Kentish Rag." *Quart. Journ. Geol. Soc.*, vol. xxii. p. 402.

In the Geological Society's Journal for Nov. 1865* attention has been drawn to the fact that very generally where calcareous beds are "piped," there seems to have been originally a layer of clay intervening between the porous bed and the limestone; and, following up the hint of MR. PRESTWICH,† it was suggested that, in the case of the pipes now under consideration, the effect of this clayey covering has been to "hold up the water which sinks through the porous beds above, and thus protect the limestone beds below *in most places*. At those points, however, where the clay is in any way permeable, much water passes down, and chemical action goes on rapidly. The clay, therefore, serves to concentrate at particular points or along particular lines that action which, were no clay present, would be distributed pretty equally over the whole area. Here we may add that, in the case of the harder limestones, MR. PRESTWICH suggests (p. 80) that the pipes are likely to have resulted from the water-wear 'being directed into given channels by pre-existing cracks or fissures;' he adds 'some gravel pipes at Maidstone afford excellent illustrations of such results.' The marked parallelism of the long pipes at Maidstone is an argument in favour of their having been originally started along joints or fissures." An illustration of this is given in Fig. 29, but in some small pipes the rag below is fairly continuous, and gives no evidence of a strong joint.

Fig. 29. Sketch of a Pipe in its earliest stage, forming along the line of a joint or small fault.

a. Sandgate Beds. *b.* Rag. *c.* Hassock.

As these pipes remain open for only a short time it may be useful to note the position of those in work when this district was surveyed, or concerning which information could be obtained by DR. C. LE NEVE FOSTER, from whose notes and maps I extract the following details:—

"In passing up the Boxley Road from the Gaol a pipe is cut at 300 feet from the west end of that road, where it enters Well

* FOSTER and TOPLEY, "On the Superficial Deposits of the Valley of the Medway," vol. xxi. p. 455.

† "On the Origin of the Sand and Gravel Pipes in the Chalk of the London Tertiary District."—*Ibid.*, vol. xi. p. 79.

Road. This pipe is 22 yards wide and 25 feet deep with gravel beneath. A good deal of Ragstone was worked away here on the south side of the road. This pipe is said to die out a little further to the south.

"At about 260 feet along the Boxley Road from the east side of this pipe, or 620 feet from the corner of the road, there is a pipe, 25 yards wide and 21 feet deep.

"On the east side of the Cavalry Barracks and close on the west of Sandling Road there are 32 feet of brickearth, no doubt belonging to a pipe, as rock occurred close by. On the open ground north-east of this there are several pipes. There appears to be one ranging along by Albert Street and Scott Street. Further east, at 580 feet from Sandlin Road there is a pipe 32 yards wide and 28 feet deep; three large pits were being worked in this pipe; it is said to die out on the north. Still further to the east is 'Goodwin's Pit,' the largest pipe of brickearth in the district. It is 50 yards wide and 40 feet deep, but loam has been dug 10 feet lower, when 'quicksand' is reached."

No doubt a great deal of the ragstone area about Maidstone is furrowed by such pipes, but they are difficult to detect when not being actually worked.

There is one at Tovil, between St. Stephen's Church and the Schools, 25 yards wide across the road, and running apparently due north.

MARSHALL describes quarries worked in 1798 at Frant and Farleigh. "In each of these quarries are seen blocks of stone of different kinds and of every shape and dimensions, separated by seams and large irregular masses of earth, of different qualities, among the rest, brick earth of the first quality. In some places; the stones are buried several feet, under these earthy materials; in others, the rock rises to the surface."*

The hollows in ragstone at Boughton, near Loose, three miles south of Maidstone, in which a great number of bones were found many years ago by MR. BRADDICH, were in all probability pipes. DR. BUCKLAND thought them caverns; and as such they are described in the Geological Society's Museum, where some of the bones are preserved. The following description was published at the time: "All these [bones] were found nearly together, within the space of a few feet in one of the numerous cracks or fissures (locally called *vents*) that intersect the strata at this place, and are usually from one to twenty feet broad. . . . These fissures or vents cut through the strata from the bottom of the quarries to the surface, and are filled with diluvial loam, interspersed with fragments of the adjacent rocks, and numerous chalk flints. . . The bones were discovered at about fifteen feet deep in one of these fissures."† It is also stated that *caves* were sometimes found in the quarries.

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* *Rural Economy of the Southern Counties*, vol. i. p. 11.

† *Phil. Mag.*, ser. 2, vol. ii. p. 73, 1827.

SIR RODERICK MURCHISON, who accompanied DR. BUCKLAND on his visit here, says:*—"Whether the cavities in which the bones occurred were really at any time inhabited caves, as our able and zealous leader wished to prove, or were simply a portion of the drift so often alluded to, I have a distinct recollection that the bones had been preserved under a copious accumulation of impervious loam and clay, which had spread over the orifices and plugged them up, at considerable altitudes."

These descriptions agree so well with the appearances presented by the Maidstone "pipes" that we are justified in concluding that the bones at Boughton occurred in a pipe and not in a cavern; and therefore that the deposit is of river origin. The distinction is important, for this is the only case of the occurrence of Cave Mammalia which has been cited from the Wealden Area. MR. DAWKINS gives the following list of bones from Boughton †:—

Hyæna spelæa, Goldf.
Cervus tarandus, Linn.
C. elaphus, Linn.
Bos primigenius, Boj.
Equus caballus, Linn.
Rhinoceros tichorhinus, Cuv.
Elephas primigenius, Blum.

On the left bank of the river, besides those in the large quarries already noticed, pipes have been observed in a quarry north-west of the *T.P.*, east of Barming Heath; here they are small. Near the Lunatic Asylum there is a good deal of loam in "vents" or pipes.

At East Malling Heath there is a large pipe, interesting from the great height above the river at which it occurs. Brickearth has been proved here to a depth of 36 ft.; it is remarkably well stratified. The *surface* here is 275 ft. above the Medway, but to obtain the true height of the deposit we must add the *depth* to which it has sunk in the Ragstone (at least 36 ft.): this gives 311 ft. above the river. It closely resembles the brickearth at Maidstone, but is more decidedly stratified than in the majority of sections there seen. This pipe appears to run about W.N.W. and E.S.E., thus differing from those at Maidstone, which are all more or less north and south.

The Maidstone brickearth pipes are very rich in Mammalian remains. They occur chiefly as teeth, of *Elephas primigenius*, *Rhinocerus tichorhinus* and *Equus*, but bones of each and tusks of the first named are often found. Stags' horns also frequently

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* *Quart. Journ. Geol. Soc.*, vol. vii. p. 383, *note*.

† *Quart. Journ. Geol. Soc.*, vol. xxv. p. 194. MR. DAWKINS' authorities are the following collections:—"Brit. Mus.; Mus. Oxford; Geol. Soc.; Chichester; Sir Ph., Egerton; Lord Enniskillen."

This deposit is mentioned by DR. FITTON, *Trans. Geol. Soc.*, ser. 2, vol. iv. p. 132, and also by PROF. MORRIS, *Mag. Nat. Hist.* (*Loudon's*), vol. ix. p. 595, who states that bones of the wolf, fox, and water-rat occurred with those of the Hyæna. DR. MANTELL has figured the jaw of a Hyæna and described it as "from a fissure in a sandstone rock, near Maidstone." *Medals of Creation*, frontispiece to vol. i. This is probably from Boughton.

occur. The following shells, which have been named by MR. ETHERIDGE, occur here :—

Helix fulva, Müller.
H. hispida (?), Linn.
Pupa muscorum, Pfeiffer.
Succinea oblonga, Drap.
Zua subcylindrica, Linn.

PROF. T. McK. HUGHES found a bivalve, either *Pisidium* or *Cyclas*, in one pit, near the Gaol. This is a fresh or possibly brackish water form; all the other species are land-shells.*

Similar bones to those named above have been found on the left bank of the river, both in the Iguanodon quarry and the quarries near Little Buckland. I did not hear of any fossils in the East Malling pit.

Wealden District.—The gravels of this area are far more important in extent than those of the Lower Greensand, but they extend to a lesser height above the streams.

At Yalding, just south of the entrance to the narrow valley or "gorge" through the Lower Greensand, the three main branches of the Medway come together; of these branches, two—the Teise and Beult—drain the country to the east and south-east, whilst the Medway itself drains the country to the west.

From near Marden on the east to Tunbridge on the west there is, over the Weald Clay, an almost continuous sheet of loam and gravel, about four miles in width, but narrowing towards Tunbridge. It is quite cut through by some of the streams, exposing the Weald Clay beneath; and, in places, clay comes up to the surface within the main area of gravel.

We will first describe the western half of this plateau, or that formed by the main branch of the Medway.

A great part of this area, especially that about Hadlow, is covered with a deep and rich loam, on which large quantities of hops are grown. Gravel usually underlies this loam, and comes to the surface in many places, whilst over large areas the surface is wholly gravelly. The gravel appears to be fairly uniform in character, always containing some flints, Tertiary and Wealden pebbles, and generally fragments of Lower Greensand chert.

This plateau of gravel and loam rises northwards from the river, and attains the height of 137 feet on the road between Goose Green and Hadlow Common. Here there is an excellent section of gravel, some 10 ft. deep, interstratified with false-bedded sand.

There is another section at the Pottery, 2 miles north-east of Tunbridge, which is interesting from showing a good example of disturbance. The beds are thrown into a sharp anticlinal or

* The fossils mentioned in the text have all been collected by the Geological Survey. In addition to these MR. BENSTED gives *Hippopotamus* (*Geologist*, 1862, p. 448) and PROF. OWEN, *Hyæna spelæa* (*Brit. Foss. Mammals*, p. 151), both from the brickearth at Maidstone. Possibly the latter is the Boughton Hyæna. PROF. MORRIS records some land shells from the Iguanodon Quarry (*Mag. Nat. Hist.*, vol. ix. p. 593).

arch.* Close at hand there is a section of brickearth, 13 ft. deep.

The high outlying patches of gravel north of Tunbridge are in part composed of angular pieces of chert, and are apparently not all true river gravel, but merely subaërial deposits left by the recession of the Lower Greensand escarpment. There are many places over the Weald Clay where such "gravel" occurs, but not often in any quantity.

The outlier of gravel near Starve Crow Farm is at its highest point 253 feet above the sea, or about 200 feet above the river at Tunbridge. This is in part a true river gravel, as flints and Tertiary pebbles occur over the north-eastern part. There are Wealden pebbles with the chert near Starve Crow. The northern outlier, east of Lit. Park, is 20 feet higher. This appears to be wholly composed of angular pieces of chert from which all the ragstone has been so completely removed that in an analysis of water from this "gravel" no trace of lime was found.

River gravel occurs in patches over North Fright Woods, and is well developed around the houses, half-a-mile north-west of Stallions Green.

The outlier at Dunk's Green, east of Shipborne, is in its southern part an ordinary river gravel with Wealden pebbles; but on the eastern side it is formed of large angular flints and Tertiary pebbles, and at one place I got a piece of *chalk*. There are *no Wealden pebbles here*. This overlooks the stream which flows down from the chalk escarpment (five miles distant) past Ightham, and it is, I believe, a gravel of that stream, marking the spot where it fell into the main river. Dunk's Green is about 60 feet above the Plaxtole stream.

This is a similar case to that before described near Allington (p. 175).

At Ensfield, one mile south of Leigh, there are five feet of gravel; about one-half of the pebbles are of Wealden sandstone, the remainder flints and Tertiary pebbles.

The gravel at Penshurst and Ford Place is of the same character, whilst the flat by South Park and Saint's Hill is chiefly loamy.

At Ford Place the river Eden falls into the Medway, and as the gravels of the tributary stream are of the same character as those hitherto described in the main valley it will be best to say a few words on them before describing the higher branch of the Medway itself, in which the gravels are of a very different character, being composed wholly of Wealden pebbles.

The gravels of the river Eden form a broad continuous fringe to that river on its northern bank, from near Penshurst Station to beyond Edenbridge. On the southern side the width of the deposit is less. North and north-east of Chiddingstone the gravel occurs only as scattered pebbles.

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* See fig. in *Quart. Journ. Geol. Soc.*, vol. xxi. p. 457.

The gravel at Camp Hill seems to be mainly composed of fragments of Lower Greensand and may be chiefly of subaërial origin.

The large gravel pit near Hever Lodge was long since described by SIR RODERICK MURCHISON.* It is probably the best known section of the Weald Clay district. The gravel here contains Tertiary pebbles, flint, and fragments of chert; it occupies a flat near the river.

The patches of gravel further west have much the same character as far as they are known. They slope upwards from the river towards the Lower Greensand escarpment and attain heights of 150 feet or more above the river near Lingfield, and 60 or 80 feet above their adjacent streams. Frequently these gravels are cemented by peroxide of iron into a conglomerate, more or less hard, which is locally known as "Crowstone" or "Crowstony gravel."

The following note is from SIR RODERICK MURCHISON'S paper (p. 380). "On the north side of Tilburstow Hill, and at a very considerable height above the valley of Godstone, the beds of chert of the Lower Greensand, which are there broken up for gravel, are covered by unstratified clay. In it are a few minute fragments of chert, chalk, and flint."†

Returning to the main branch of the Medway, which now runs only through Hastings Beds, there is a pit south of Willard's Farm where 10 feet of gravel are seen, in which I found two fragments of flint, but all the other pebbles were Wealden excepting one of quartz of doubtful origin. In this pit there is a *synclinal* arrangement of the gravel resembling that at Wateringbury (p. 175) and like it probably formed by disturbance, for it seemed hardly explicable by false-bedding. The beds of gravel dip 10° to the north-east and then rise again at 5°. All the beds dip alike, even the finer laminæ of sandy clay.

The gravel north of Ashurst occupies a sort of bay or hollow, rising about 35 feet above the stream; it is wholly composed of Wealden pebbles.

In the railway cutting west of Ham Bridge there was a good section of gravel exposed, wholly of Wealden pebbles.

In the cutting east of Groombridge there is a little gravel, at some height above the stream. Loam is seen in the cutting north of the High Rocks, 12 feet thick, but some of this may be rainwash.

At Ball's Green there is gravel, whilst at Summerford, on the north side of the river, the old alluvium is chiefly loam.

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* *Quart. Journ. Geol. Soc.*, vol. vii. p. 381.

† I do not know the section here referred to. Probably it is not a gravel; but the "chalk and flint" may be the remains of the Chalk which once spread over here. It is certainly a remarkable position in which to find *chalk*. MR. WHITAKER suggests to me that possibly disintegrated whitened flint pebbles may have been taken for Chalk.

In the railway cutting north-east of Hartfield there are in one place 8 feet of gravel. In another place there is brickearth, 6 feet thick, with gravel beneath.

The most considerable sections of gravel in this higher branch of the Medway are at Line's Farm, two miles west of Hartfield, where it appears to contain Wealden pebbles only. In one place 14 feet of gravel are seen, distinctly stratified, and containing thin layers of loam.

Gravel has been observed in the railway cutting south-west of Redgate Mill. This is in the branch of the river which rises at Rotherfield and falls into the Medway at Ham Bridge. Some of the fragments are large; all are Wealden. The gravel lies 30 or 40 feet above the stream.

The gravels of the Beult and Teise, the eastern tributaries of the Medway, are almost wholly made up of Wealden fragments. The southern gravels, near the Hastings Beds, entirely so; whilst on the north there are some few foreign pebbles intermixed.

Flints and Tertiary pebbles have been observed as far east as Hersfield Bridges, but they are exceedingly rare and the gravel is almost wholly composed of Wealden pebbles.*

The old alluvia of these eastern streams contain less brickearth than do those of the western branch. Sections are seen in the railway-cutting at Marden, where the fragments are Wealden only. This section is interesting as being the only place, south of the Greensand at which bones have yet been observed in the Medway gravels. They were found in making the railway-cutting "in blue marl, under a bed of gravel, about twenty feet thick."† Here and at Wantsuch Green, a little to the north-east, the gravel caps low flat hills, separated by bare clay slopes from the lower terrace bordering the streams.

The lower gravel of this district was observed by Dr. Foster sometimes to lie with an uneven junction upon the clay, occupying shallow depressions. These hollows run in more or less parallel lines, and between them the clay sometimes comes to the surface.

The following sketch shows the arrangement of the gravel on the north of Frittenden and near Underhill's Green.

Fig. 30. Sketch of Gravel lying with an uneven surface on Weald Clay.

* In some of these gravels, and occasionally on the surface of the clay, we find largish quartz pebbles, the origin of which is uncertain. Dr. Foster has found them as large as a hen's egg. I found a *fragment* near Chiddingstone of which the measurements were 3 in., 2 in., 2 in.; but generally the pebbles are much smaller than these. They also occur, but more rarely, over the Hastings Beds of the western part of the Weald. We rarely find pebbles larger than a pigeon's egg in the Wealden conglomerates; but Mr. H. Willett informs me that in the conglomerates at the Quarry at Whiteman's Green, Cuckfield (see p. 91), quartzose pebbles of much larger size sometimes occur.

† *Geologist* [Moxon's], 1842, p. 198.

A somewhat similar occurrence to this has been described by Mr. Godwin-Austen in the gravels of the Wey (see p. 198). This arrangement of gravel and clay requires a modification of the ordinary mode of land drainage. It is essential that the drains should run more or less transversely to these lines of furrows. The Keythorpe system of drainage originated upon land of this kind, where gravel overlies Lias clays.*

The gravels of the Beult extend eastward in a narrow band along the streams to beyond Smarden, and there are some out-outlying patches to the north of the river. The gravel mentioned on p. 169 may also belong to this stream.

The Beult flows over Weald Clay from east to west, only some of its small tributary brooks coming down from the Hastings Beds. The Teise runs on the south of Tunbridge Wells and flows *eastwards* at far as Goudhurst and then northwards out of the Hastings Beds to the Weald Clay flat. It thus repeats exactly the course of the main branch of the Medway. In this valley there are some deposits of gravel.

Near Mole Farm, south-east of Horsemonden, a pit shows 9 feet of gravel wholly composed of pebbles of Wealden sandstone and fragments of clay-ironstone. At Finchcock's the gravel is 20 feet thick; falsebedded in places, with sand and loam. Some of the pebbles are large.

At Court Lodge, Lamberhurst, the gravel is 8 feet thick, and lies about 20 feet above the stream.

River Darent.

The gravels of the Darent Valley occur in greatest force just within the Chalk escarpment. They are not found on the east of Seal, but extend up the Darent Valley westwards as far as the watershed, on which there is a patch of gravel of considerable interest. In composition the gravels of the Darent differ from those of all other Wealden rivers, in that they contain no trace of pebbles of Wealden sandstone. The chief components of the gravel are chalk-flints intermixed with rounded Tertiary pebbles and fragments of Lower Greensand chert. The quantity of brick-earth is small.

The most important sections of gravel, or rather those which afford the best evidence of its composition, are seen in the railway cutting near Broughton House. The South-Eastern railway to Sevenoaks was in progress at the time these gravels were surveyed, and the sections now to be described were plainly seen, but are now probably obscured.

Broughton House stands on a spur of the Lower Chalk. The highest ground of this spur is 358 ft. above the sea, or 158 ft. above the river at Otford. The gravel occurs all over the highest ground, and is let down into the chalk in "pipes." To this cir-

* See Mr. Trimmer's paper, *Journ. Roy. Agric. Soc.*, vol. xiv. p. 96.

cumstance is owing the preservation of considerable thicknesses of gravel in places. The beds are distinctly and very regularly stratified. The following section was measured in a pipe; although let down into the chalk there could be no doubt that the beds were in their proper relative positions :—

	Ft.	In.
Coarse Gravel	2	0
Loam	1	0
Coarse Gravel	1	0
Loam	1	0
Coarse Gravel	4	0
Coarse Sand	0	6
Gravel	3	0
Sand	0	6
Gravel	1	6
Clay	0	4
Fine Gravel and Sand	4	0
	18	10

Tertiary pebbles were rather abundant. There were also flints and some small quartz pebbles.

The pipes were lined with a stiff brown clay; perhaps mainly due to the dissolving away of the chalk, as in the case of clay-with-flints on the surface of the Upper Chalk, or the clay lining pipes on the top of the escarpment. The Lower Chalk contains more argillaceous matter than the Upper Chalk, but no flints; hence a small amount of this if dissolved would leave a quantity of clay, but no black flints. Perhaps, however, in this case the clay is not wholly due to the dissolving away of the chalk, as it extends somewhat beyond the gravel covering on the south slope of the hill, and is there not let into pipes (Fig. 31). Possibly clay formed the lowest bed of the old alluvium, and the presence of this has caused the pipes, just as the Sandgate Beds appear to have caused the pipes of brickearth at Maidstone (see p. 181).

Fig. 31. *Sketch on side of Railway Cutting near Broughton House.*

a. Gravel. *b.* Clay. *c.* Chalk.

The gravel occurring over the higher ground near Broughton House is an outlying patch or high terrace, but on the north-eastern slope of the hill the gravel gradually descends, or has probably been washed down the hill, so as to join the lower terrace. The stippling has therefore been continuously shown on the map.

The relation of the Broughton House gravel to that at lower levels is shown on Fig. 32. This also shows the position of the gravels near Seal, which are really divisible into two terraces, as in the sketch, but the lines come so closely together that all has been stippled together on the map.

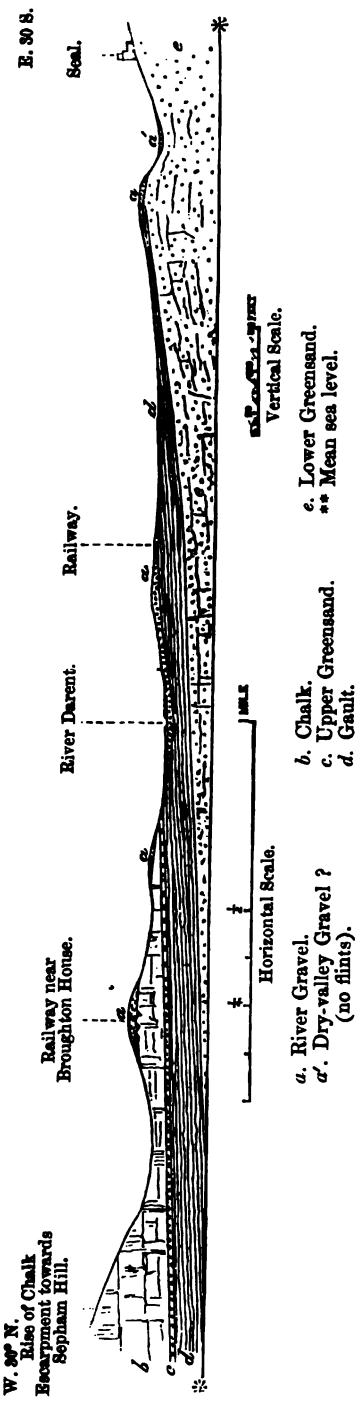


Fig. 32. Section across part of the Darent Valley.

The gravel in the valley near Seal (*a'* of sketch) and, in a less striking degree, that on the hill just north-west of this, is somewhat peculiar in character. A good section of it is seen on the south side of the road about half way between Seal and the T. P. Gate west of it. The gravel consists almost entirely of chert and Lower Greensand iron-sandstone, with many small quartz pebbles. Flints and Tertiary pebbles appear to be absent. The fragments are often large, only subangular, and some seem hardly at all worn. There are occasionally some small beds of coarse sand interstratified. At one point there are 3 or 4 ft. of impure loam above the gravel.

This gravel lies in a hollow now dry, but down which a stream once flowed in a north-easterly direction, towards Kemsing.

The gravel on the higher ground north of this pit has occasionally some flints, but appears to consist mainly of Lower Greensand fragments.

A gravel of somewhat similar kind is seen on the top of the railway cutting near Riverhead. Here it consists chiefly of partially decomposed chert, and may be little more than the remains of Lower Greensand decomposed *in situ*. That at Seal, however, has certainly been carried into its present position, but, from its angular character, it can have travelled only a short distance. A patch of angular gravel also occurs in Montreal Park, just east of the house.

The area which is stippled for gravel on the Map (Sheet 6) between Seal and Otford, is in great part obscure. Much of it near Seal is covered with the angular gravel just described; near the Railway it is gravel of the more common kind, whilst in the intermediate part the land is much covered with flints.

Near the brickyard west of Froghall Farm the wells, on passing through 6 or 8 ft. of gravel, come upon a "quicksand" which yields water. This appears from some samples turned out to be re-arranged Folkestone Beds. There is hereabouts some brick-earth overlying the gravel.

The lower ground about Sundridge and Brastead is much covered with loam, but there is also a good deal of gravel. In a pit near Comb-bank there were several rather large blocks of stone; one measuring 17 in. × 8 in. × 4 in.; another 15 in. × 10 in. × 6 in. I omitted at the time to note the character of the stones, but am inclined to think that they were chert.

On the higher ground, south of Brastead, there are the remains of a gravel terrace, occurring now only in small patches. The river due north of Dry Hill Farm is 250 feet high; just south-east of Brastead Park Farm it is cut by the 300 feet contour. The lower terrace at Brastead is all below the 350 feet contour, but about touches it near Sundridge Church. The remains of the higher terrace are wholly above the 350 feet contour, and at times slightly exceed 400 feet.* Between Dry Hill and Wester-

* The river Darent is 350 feet above mean sea-level at Westerham, 200 feet at Otford.

ham there are seven patches of this higher terrace, all small and some barely visible on the one-inch map; most of them occur on outliers of Folkestone Beds. They all contain pebbles from the Tertiaries in great numbers, with flints and fragments of chert and Lower Greensand ironstone.

These patches have in every case a distinct relation to the present valley of the Darent, and they are backed on their southern side by high ground over which there are no traces of gravel.

Brickearth has been dug to a depth of 10 feet near Sundridge Church, and all over this flat there seems to be a good deal of loam. I could hear of no shells or bones being found. Just south of the Paper Mills, east of Sundridge, there is a gravel which seems to be intermediate in position between the lower terrace and the fragmentary portions of the higher terrace. This occupies the eastern part of the stippled area on the Map at Sundridge; it ends off fairly sharply on the eastern side, but on the west it runs into the loam of the adjoining flat.

A good deal of the gravel between the Paper Mills and Chipsted is of the angular kind, as is some of that near Bradbourn Farm.

South-east of Westwood Farm, one mile west of Westerham, some brickearth is dug which appears to be an old wash from the Gault. It contains some flints, like those which frequently occur over the surface of the Gault, and in some places it becomes very stiff, and closely approaches the weathered Gault in character.

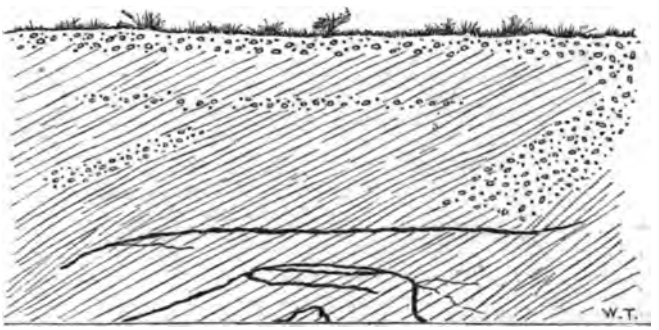
There is brickearth on the north-east of Dry Hill Farm, which extends eastwards along south side of the wood towards Cold Harbour (not marked on the map), and from thence, still eastwards, towards Briton's Farm. I saw no section of this, but from the description given it appears to lie in a hollow in the ragstone, perhaps somewhat resembling the pipes at Maidstone, but of its dimensions I have no information. In its mode of occurrence this brickearth is peculiar; for it is separated from the river by rising ground, occupied by Folkestone Beds.

Loam occurs on the east of Seal just at the *l* of *Seal Chart*, and again just east of the Crown Point Inn. In both cases the brickearth lies in a hollow of the Folkestone Beds and appears to be only a rainwash. Between these points, and just east of that first mentioned there is some "gravel." This is only decomposed chert with loam, the solid chert appearing beneath. The brickearth may be this loam washed into the hollows.

On the outlier of Folkestone Beds, about midway between Sundridge Church and Brastead Farm, is a small patch of gravel which presents some remarkable appearances at its junction with the sand. The gravel, as seen in a sand-pit, is about 3 feet thick and rests on sand dipping at a high angle, 25° or 30°, to the east; this is probably false-bedding. The remarkable point is that the gravel seems to pass *into* the false-bedded sand. There are small pieces of flint and Tertiary pebbles in the sand; in one place there is a continuous line of them, with the lines of false-bedding continued above. These appearances are shown in

Fig. 33. The irregular dark lines below are ferruginous infiltrations. There can be but little doubt that the sands are true Folkestone Beds and that the gravel is a modern deposit, but how the former could have been re-arranged in the manner described is hard to understand.

Fig. 33. Re-arranged Folkestone Beds and Gravel.

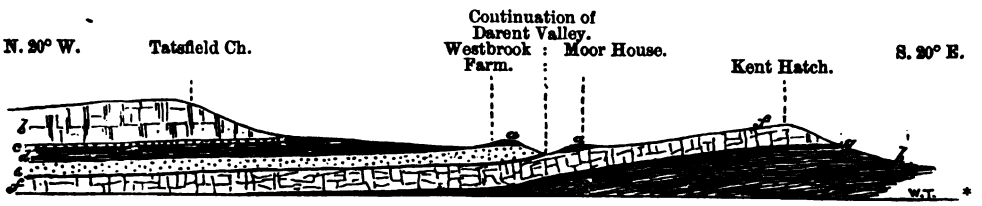


This outlier of gravel is one of those before mentioned as lying between Dry Hill and Westerham. West of the latter place the gravel still occurs in patches, which need not be further described. On Bowling Green, near Limpsfield, there is a larger patch, lying on the watershed of the Medway and Darent. As this gravel is interesting on theoretical grounds it may be well to describe its character. It contains flints and Tertiary pebbles chiefly, but fragments of Lower Greensand are scarce. The flints are large, all broken, and more or less waterworn. The round pebbles from the Tertiaries are often entire, and when broken, always show signs of subsequent wear. The gravel is mixed in some places with some red sticky clayey sand, and is sometimes stained blackish. Generally it presents an appearance of bedding, but in a few places it is coarsely stratified with sand and finer gravel.

I know of no other gravel within the Weald, and certainly there is none in the three north-eastern valleys, which in position resembles this at Limpsfield. In character it somewhat resembles that at Warren House, on the eastern branch of the Stour; but the latter is not on the watershed. It is, however, in great quantity for so high a position in the valley. Possibly these two gravels may be related to each other, but there is no trace of any similar gravel in the intermediate valley of the Medway. The most interesting point about it is that it lies *on the watershed*, and cannot therefore be referred to the river Darent in its present orm. It is quite certain, however, that the gravels of the Darent Valley from near Westerham westwards have a distinct relation to that of Limpsfield. They, too, are somewhat unlike ordinary river gravels in appearance, and are, in extent (though small) out of all proportion to the modern stream; the higher part of the valley above Moor House is in fact dry. These patches are

evidently merely the watershed gravel, re-sorted by the streams when they were more important than now. That they are well within the valley of the Darent is shown by the following section taken across the valley near Moor House.

*Fig. 34. Section, 1½ mile West of Westerham.**



a. Gravel
b. Chalk.
c. Upper Greensand.
d. Gault.
e. Folkestone Beds.
f. Hythe Beds.
g. Atherfield Clay.
h. Weald Clay.

* * Sea Level.

One other section remains to be noticed. On Limpsfield Common is a brickearth pit showing reddish mottled clay which becomes sandy below. The sand is sometimes whitish and contains some green grains; below this again is sandy loam. The greatest thickness seen is fifteen feet. Thin beds of sand with green grains are common, and in places there are a few flints and Tertiary pebbles in the brickearth. This is due south of the gravel on Bowling Green: it, too, is on the watershed.

River Mole.

The greater part of the basin of this river, within the Weald, is occupied by Weald Clay. The Lower Greensand district being narrow excepting for a small area near Nutfield on the east, and a still smaller area near Leith Hill on the west. Over the Greensand about Dorking, and for about three miles west of that town, there is gravel, but the greater part of the area is free from any superficial deposit. The Hastings Beds on the south are apparently altogether free from gravels. The area of this formation included within the Mole Valley is about equal to that of the Greensand and Gault. Over the Weald Clay there is a great deal of gravel.

The southern line of watershed rises to about 500 feet and the outcrop of the Hastings Beds varies for about 200 to 250 feet. On the Weald Clay there are but few points which rise above 300 feet, and these are along the ridge formed by the outcropping of a layer of Paludina Limestone. At the foot of the Lower Greensand escarpment the level of the clay often rises above this height. The Lower Greensand area is mostly much below 500 feet; there

* In this section the northern patch of gravel is drawn to too high a level, and the flexure of the beds just north of Moor House is understated, the dip should be greater.

are a few points on the east, near Nutfield, which slightly exceed this, and on the south-west, the highest point is Anstie Bury (808 feet), near Leith Hill.

On the Weald Clay, near the Lower Greensand escarpment towards Leith Hill, chert and loam often occur, sometimes capping the hills; these are not river gravels, but are probably a wash or subaërial deposit left by the escarpment. The fragments are generally angular, or have their angles slightly worn by weathering.

The following notes are by MR. F. DREW: "On the southern part of the Weald Clay district the gravel is composed of small pebbles and flattish pieces of sandstone and iron-sandstone from the Wealden, chiefly I think from the Hastings Beds. This is found only on the very level plain which is bounded on the north and west by a range of hills running from Gay House Farm (about four miles south of Bletchingley) and Outwood Common to near Charlwood and Rusper, and on the south by the smaller rise of the ground near Ifield, Crawley, and Three Bridges. It occurs sometimes in patches, sometimes as a more continuous layer. I have not seen a greater thickness of this than four feet, but there may be more in places; sometimes there is but a foot or two feet. Here and there sand occurs with the gravel, and at the surface the latter is sometimes cemented by peroxide of iron into a loose conglomerate, which soon decomposes on exposure, and goes by the name of 'ragstone.'

"At Dean Farm, two miles south of Redhill, the gravel has a different character, and consists of red jaspery-looking angular flints and a little ironstone mixed up with loam. On Earlswood Common much the same thing occurs, but with fewer flints and more ironstone, and at Staplehurst, a little to the east, there is gravel with some 'ragstone.'

"The high ground of Leith Hill is without drift, but in the valley between that place and the Chalk ridge gravel occurs occasionally. At Milton a section by the road side shows ironstone-gravel lying irregularly on white sand, and there is a like gravel on the south of Dorking.

"About Brockham Green and Betchworth, where the ground is flat, there is a great deal of drift, which reaches southwards to the outcrop of the Weald Clay; but further east, beyond Buckland it occurs only in the usual way, that is in patches, which rest chiefly on the Gault and the uppermost part of the Lower Greensand, with the exception that over a flat taken up by the Folkestone Beds between Redhill and Merstham on the west, and Brewer Street on the east, there is a fairly thick deposit of brick-earth or a more clayey wash."

Mammalian remains have been recorded from the following localities in the Mole Valley :—*Elephant* from Charlwood,* Dorking and Betchworth†; *Rhinoceros* and *Elephant* from Petridge Wood Common.‡

* MARTIN.
† MORRIS, *Mag. Nat. Hist.*, vol. ix. p. 46.
‡ MANTELL, in BRAYLEY'S "History of Surrey," vol. i. p. 129.

River Wey.

This is the most important of the northern rivers, excepting the Medway. It drains a larger area of Lower Greensand than any other Wealden River. The main branch rises near Alton and flows east-north-east to Farnham where it turns south-east to Tilford Bridge; here it receives an important tributary from the west, then again turning east it flows past Godalming and turns northward to the Chalk at Guildford. The tributary which falls into the Wey at Tilford Bridge is fed by a number of brooks which rise between Selbourne and Binstead, generally at the base of the Upper Greensand; whilst the streams which feed the Wey itself take their rise often in the Upper Greensand itself and flow *over the* Chalk to the north and north-west. The drainage of this north-eastern corner of the Weald is exceedingly curious and unlike that of any other parts of the district. The eastern branch of the Wey, the Tillingbourne, rises on the northern slopes of Leith Hill and flows westwards. The southern branch, which drains the Weald Clay area, is fed by some small brooks rising near the county boundary, and by others which rise at the foot of the Lower Greensand escarpment. The stream which runs the longest course rises on the north of Ewhurst at the foot of Holmbury Hill. This and the eastern branch fall into the Wey at Pease Marsh.

The area drained by the southern branch is a comparatively flat plain, but rising into low hills near the Lower Greensand escarpment. The basins of the other branches contain some very high land in these southern parts, rising to heights of 800 and 900 feet.

The low ground at Pease Marsh is very much covered with gravel and sand, deposited by the united rivers. Much of the sand so closely resembles that of the Folkestone Beds that it is extremely difficult to distinguish them in small sections. This alluvial sand however generally overlies the Weald Clay of the Pease Marsh inlier, and often contains small seams of gravel.

The gravel extends from Pease Marsh up the Tillingbourne in a continuous sheet as far as Albury. That of the Wey itself occurs only in detached masses above Godalming, until we come to Farnham, where there is again a broad and continuous spread. Flints are scattered about over the high land of Farnham, Frensham and Thursley Commons, and over Alder Holt; but these are probably the remains of the Chalk which once covered the lower beds and are not a deposited gravel. It does not appear that the gravels of the Wey occur at any very great heights above the present streams.

Mr. Godwin-Austen has described in some detail the deposits of Pease Marsh and the Tillingbourne stream.* Beneath the gravel in some places there are traces of a forest-growth, which,

* *Quart. Journ. Geol. Soc.*, vol. vi. p. 90, vol. vii. p. 278, and vol. xi. p. 112.

so far as I know, has not been observed in any other Wealden valley. The following is an extract from the latest of the papers just referred to:—

"The great sheet of gravel and brick-earth which is spread out over Wonersh Common runs out to the edge of the depression in which the Tillingbourne stream flows. The gravel beds are cut off abruptly, and are from 8 to 10 feet above the level of the water, measuring to their lowest line. In the course of some works connected with the formation of water meadows in East Shalford, a water-course was carried along these beds for a considerable distance. They were seen to consist of gravel and sands, with diagonal bedding, showing an arrangement by running water, . . . and containing Elephant remains. At a spot near where the road from Wonersh Common to East Shalford Farm crosses the water-course, and afterwards the Tillingbourne, a good section was exposed, which had, when I first saw it, been swept clean by a large body of water having been turned through it. The section showed

1. Drift gravel; 8 feet.
2. Bed with black vegetable matter, seemingly composed of matted roots, with occasional trees, the whole associated with fine marly beds.
3. Neocomian clay.

"The roots of the larger trees descended into the subjacent clay. There were also smaller stems, with a bark like that of the hazel; but the wood had perished.

"This terrestrial surface was identified again about a mile higher up the valley, near Tangley Pond, beneath about 18 feet of gravel; and consists of marly beds with much vegetable matter, and blending with the sands and gravels above. This locality is not on the line of the present stream, but is a part of what formed a low tract before the overspread of the gravel; and, as a general rule, it will be found that the Elephant remains are always most abundant in the gravels which occur about such spots. In the instance which has just been noticed, as in every other, there was a total absence of any detritus below this old terrestrial surface."

The gravel is seen in the railway cutting east of the words *Pease Marsh*, resting on clay. It is here four feet thick and contains flints (mostly subangular), Tertiary pebbles, chert, Lower Greensand ironstone, and layers of false-bedded sand. A little further south-east there is a thin layer of clay in the gravel.

Sand is seen in the cutting just west of Shalford Station resting on stiff blue clay (Weald Clay). North of Gosden House sand is seen in the railway cutting, and there is a pit north-east of Unsted Bridge. All the land around Gosden House seems to be occupied by this sand, which greatly resembles Folkestone Beds in appearance.

It was in a gravel pit in Pease Marsh that MR. WHITBURN discovered a flint implement many years ago.

The gravels of the Tillingbourne rise from the stream southwards up the side of the valley; on the north of the stream the

ground rises more rapidly and is generally free from drift. At a point half a mile west of the Locknor railway cutting MR. GODWIN-AUSTEN observed an interesting example of apparent disturbance in the gravel.* Here the gravel rests on Atherfield Clay, and the effect of the disturbance, if such it be, has been to cause a succession of ridges and furrows of clay under the gravel resulting in an arrangement somewhat resembling that described on p. 188. MR. GODWIN-AUSTEN says, "I had often heard from persons in the occupation of lands along the Tillingbourne Valley, that the surface subjacent to the gravel-beds presented a series of long parallel furrows or troughs, running in the direction of the valley, or east and west; this was ascertained in draining the land, and it is now found sufficient to cut across these troughs and then allow the water they hold to run off." "The existence of this particular clay-ridge was previously known, from the area of wet land it caused to the south of it."

In the similar cases already cited from the Medway streams there is no reason to suppose that the beds have been at all disturbed; the gravel seems to have been deposited in hollows formed by the streams in the clay. This explanation may suffice for most of the cases cited by MR. GODWIN-AUSTEN and for one shown in the sketch, but in the other case there appears no doubt that the beds have been disturbed, though I think not to the extent assumed. The *re-arrangement* of the gravel is probably false-bedding and the inclined arrangement of the gravel as a whole, or the slope downwards from the high ground on the south to the stream on the north, is probably owing to the gradual excavation of the valley from south to north.

The following notes, by MR. F. DREW, probably refer to subaërial gravels:—

"On the west of St. Martha's is a drift consisting of loam and sand with fragments of ironstone, some of which are very large. Below Newland's Corner there is a thickness of about six feet of loam with fragments of chalk, and about 150 yards north of the stream there may be seen a mixture of flints, fragments of chalk and ironstone from the Lower Greensand, resting on a more sandy gravel of flints and ironstone. At many places on Farley Heath there is a sandy gravel containing slightly rounded pieces of ironstone, yellow sandstone, and chert, all from the Lower Greensand, near Wotton House, at the east end of the Wey basin, there is a little brickearth overlying sandstone gravel."

The following notes of the Weald Clay gravels were taken along the line of the Guildford and Horsham Railway.

Just east of Rowley Farm there is gravel, chiefly composed of Wealden sandstone, but with some chert. It is covered in places by a stiff yellow and white clay, whilst further north Weald Clay comes out from beneath the gravel. Gravel also occurs along

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* *See* sketch in *Quart. Journ. Geol. Soc.*, vol. vii. p. 284; and a similar case already described in the Medway gravels. (See p. 187.)

the railway further north, and is seen in several places over the adjacent flat.

At Cranley Station there is gravel two feet thick, overlying clay.

A fine section of gravel is seen in the railway cutting east of Snoxall Farm; it is about 12 feet thick at one place and contains Wealden sandstone, chert, and Lower Greensand ironstone. There are layers of false-bedded sand. A rough observation with a small aneroid gave a difference of 60 feet been the highest point of the gravel which caps the hill and the adjacent stream.

At Newhouse Farm there is a thin capping of gravel resting on clay.

In the cutting just south of the stream and near the *L* of *Linacre F.* a small quantity of gravel is seen.

The fragments of Lower Greensand which occur in these southern gravels are probably derived from the waste of the Lower Greensand escarpment. In the Weald Clay country of the Arun basin, immediately east and west of this branch of the Wey basin, there is a great deal of subaërial Greensand débris, as will be noticed presently when speaking of the river Arun. This still remains here, often capping low hills near the watershed; whilst in the Wey it has been collected into gravels by the streams. Some of the fragments may have been brought by streams which rise at the foot of the escarpment, but probably by far the greater number have come into the gravels in the manner described. There appear to be no flints in these southern gravels.

The gravels of the higher branch of the Wey present no points of especial interest. The largest patch found is that near Farnham, where the gravel is agriculturally of some importance as it lies partly on Gault clay.

The gravels nowhere rise to any considerable height above the river. Elephant remains have been found near Waverley, at Farnham, and at Froyle.

The Elephant is thus found to be freely distributed amongst the Greensand gravels of the Wey, but remains of other mammalia are rarely found. DR. BUCKLAND obtained the pelvis of a rhinoceros from "loam" near Chilworth.* MR. DAWKINS informs me that this was from a subaërial deposit, and not from a river gravel.

RIVER ARUN.

The basin of the Arun extends quite across the Weald Clay flat to Leith Hill, dividing the southern parts of the Mole and Wey basins; it passes behind and to the south of that of the Wey, and again reaches the northern Lower Greensand escarpment at Hascombe.

The north-eastern part of the Arun basin is rather curious. It extends in a north and south line from the south-western part of

* MURCHISON, *Quart. Journ. Geol. Soc.*, vol. vii. p. 378.

St. Leonard's Forest to Leith Hill, a distance of 11 miles, but just on the west of Slinfold the basin narrows to three miles, it being shut in by the Wey on the north-west, and the Adur on the south-east. The streams which drain this area rise in St. Leonard's Forest and at Leith Hill. Those streams which rise at Leith Hill thus have their source only four miles from the *North* Downs, but they go to feed a river which escapes through the *South* Downs. The north-western Weald Clay area is drained by streams which fall into the main river at Wisborough Green; but the extreme west of the Weald Clay is drained by streams which, flowing southwards through the Lower Greensand, fall into the Rother: the chief of these is the Lod.

The Rother is really the main stream of the Arun, it having a longer course than any of the Wealden branches of that river. It rises in the Chalk at the foot of Nore Hill and drains the whole of the south-western Lower Greensand area.

The northern part of the Weald Clay, near the Lower Greensand escarpment, is much covered by subaërial deposits such as have already been noted in the Mole Valley. The following notes are by MR. DREW:—

"Between Chiddingfold and Hambledon Hurst a road-section shows the following beds, which differ from those usually to be seen:—

	Ft.
Loam, with stone from the Lower Greensand - - -	0½
Red Clay - - - - - - - -	0½
Loamy sand, with Greensand pebbles here and there - -	5
Coarse sand, with layers of Greensand pebbles - - -	1
Weald Clay.	

"This gravel mostly occurs in patches a foot or two thick, and is found as often on the hills as in the valleys. The soil it gives rise to is generally called 'shravy,' and the stone that is sometimes formed by the cementation of the gravel by peroxide of iron is called 'ragstone.'

"About Fisherlane Wood and Dunsfold Green (S.E. and E. of Chiddingfold) there is some of this ragstone conglomerate.

"On the top of the hill at Rudgwick, and in the valley at Cradle's, near Rowhook (on the east) there is gravel. Both these places are five miles from the Lower Greensand."

There is a good deal of river gravel over the Weald Clay in places. Near Slinfold there is much gravel, said by MR. MARTIN to contain flint pebbles.* A pit near the alluvium north-west of Pencil Farm showed 5 feet of gravel, consisting mainly of Wealden sandstone, but with some Lower Greensand ironstone and chert; I saw no flints here. There is gravel seen in places higher up the stream, generally consisting of Wealden sandstone, but at Amy's Mill, one mile south-east of Horsham, MR. DREW obtained a fragment of flint from the gravel. This is

* *Phil. Mag.*, ser. 4, vol. vii. p. 168.

one of the very few instances in which flints occur in the Hastings Beds country. It is, however, close upon the Weald Clay.

Gravel occurs along the Rother from near Pulborough westwards, partly concealing the Gault, which is brought in here by a synclinal fold. There is a good deal of gravel at Cowdry Park, and in other places up the valley in smaller quantities. It has not been observed far from the river, or at any considerable height above it.

Over a great part of the Lower Greensand of West Sussex, particularly in that part of it drained by the Rother, there are great accumulations of angular flints; sometimes they are of considerable size, at others they seem much broken up. They occur in great quantity on the south-east and south of Midhurst, and also over the high ground of Rogate Common.*

I think it doubtful if these flints are part of a river gravel; and would rather regard them as the remains of the Chalk left by the recession of the Chalk escarpment. This explanation, however, is not very satisfactory, for the flints occur in considerable quantities, and often present a much more broken appearance than those found on the Gault, the subaërial origin of which is tolerably clear†.

Bones of the Mammoth were found at Burton Park in 1740, and were described in the "Gentleman's Magazine" for 1757.‡ Probably these were from river gravel. Elephant remains have also been found in the Arun gravels at Wiggonholt, and again in the Chalk gorge at Peppering. At the latter place they occurred at a height of 80 feet above the river.§

River Adur.

The greater part of this valley, within the Weald, is on the Weald Clay flat. Its northern limits take in the rising ground south of St. Leonard's Forest; to the north-east it embraces some of the Hastings Beds; and here, about Cuckfield, the ground near the watershed is about 370 feet high. On the Weald Clay near Itchingfield the height of the watershed is about 280 feet, but the greater part of the Weald Clay area within this river basin is below 200 feet; perhaps the average height would scarcely exceed 100 feet. The height of the Lower Greensand area is inconsiderable, and is least along the southern side of the "Greenhurst anticlinal."

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* Sir R. I. Murchison has given a full description of the distribution of this "flint drift." *Quart. Journ. Geol. Soc.*, vol. vii. p. 356, &c.

† May they be the remains of the higher part of the Great Hampshire sheet of gravel in its easterly extension? See Mr. Codrington's paper "On the Superficial Deposits of the South of Hampshire and the Isle of Wight." *Quart. Journ. Geol. Soc.*, vol. xxvi. p. 528 (1870).

‡ Vol. xxvi. pp. 198, 588.

§ A description of the bones is given by Dr. Mantell, "Geology of the South-east of England," p. 41.

Gravel covers a good deal of the Weald Clay flat, but its boundaries have not been traced here. There are great numbers of flints in the gravels around West Grinstead, and also along the line of the Horizontal Section (Sheet 75) between Hookland Farm and Benton Place, two miles south-west of West Grinstead.

It would be interesting to learn how far up the streams the gravels contain chalk flints. Those of the small streams to the north-east, if any occur there, would probably contain pebbles of Wealden sandstone only.

Gravel covers the Gault and Lower Greensand on the north of Steyning, and, in smaller patches, passes down the Chalk valley southwards.

River Ouse.

The gravels of the Ouse are not of any great extent. The most considerable deposits now remaining are, perhaps, those at, and south-west of, Lewes. Passing northwards towards the Weald we find a small patch at Barcombe, which is of interest chiefly from having so long been quoted as a *sea-beach*, produced during the denudation of the Weald.* It occurs around the village of Barcombe, and again just north-west of Barcombe Station. It consists of chalk flints and Wealden sandstone, with some other fragments, probably from the Lower Greensand. This is on Weald Clay. There can be no doubt that this is a river gravel: mammalian remains have been found here.† Gravel also occurs near Hamsey and Wellingham.‡

Flints are occasionally found lying over the surface of the Weald Clay in this district. These are not connected with river gravel, but are probably the remains of the chalk which once covered the whole area. From these the flints in the Barcombe gravel have probably been derived. When we pass northwards, and enter the Hastings Beds country, where the surface is quite free from flints, we cease to find them in the river gravels. Here there is nothing but Wealden sandstone. The northerly limit of the flints hereabouts appear to be about the outcrop of the Hastings Beds. Dr. Mantell mentions gravel at Isfield and Little Horsted,§ and no doubt deposits occur at many points up the river. It is seen at Sharp's Lock, where there is also some brickearth. Higher up the valley east of Sheffield Bridge, and still further up towards Lindfield, the slopes near the river are partly covered with loam.

In the eastern branches of the Ouse Valley the alluvium is fringed with loam and gravel in many places. Gravel is seen in

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* Lyell, *Principles of Geology*, 1st Ed., 1833, vol. iii. p. 296; "Manual," 5th Ed., 1855, p. 287.

† Godwin-Austen. *Quart. Journ. Geol. Soc.*, vol. vii. p. 288.

‡ Mantell, *Geology of the South-east of England*, p. 29.

§ *Ibid.*, p. 29.

the railway cutting east of Buckham Hill in patches on the hill side, whilst the flat near the river is covered with loam.

In the north-east corner of Buxted Park there is a pit showing four feet of gravel overlain by an equal thickness of loam. The gravel contains only pebbles of Wealden sandstone and is distinctly stratified. It is but slightly raised above the modern alluvium.

Gravel occurs in small quantities higher up the valley, but it has not been observed at any great height above the stream. It seems to occur in the greatest quantity around the farm buildings due north of Five Chimnies.*

River Cuckmere.

This is by far the smallest of the Wealden rivers, and of the gravels within it I have but little account to give. Sir Roderick Murchison describes, "Mounds of loam and sand with broken chalk-flints extending southwards from the zone of Weald Clay at Arlington and the station of Berwick to the gorge south of Alfriston, at which place large blocks of tertiary grey-weather-sandstone occur as boulders.

"These heaps of detritus occupy low hills considerably above the present drainage. . . ." †

In a few places over the Weald Clay there are small patches of gravel. At Michelham Priory it consists mainly of Wealden sandstone, but there are a few flints.

River Ashburn.

The only drainage area now undescribed is that southern corner of the Weald which is enclosed between the watershed of the Cuckmere on the west, and the main central line on the north and north-east.

The most considerable stream of this district is the Ashburn, which rises near Woods Corner at Dallington and flows past Ashburnham into Pevensey Level. It is joined at Boreham Bridge by another stream, which drains the country to the north-west. There are several smaller streams which flow direct into the sea, the most important of which is the Asten, which passes out at Bulverhithe.

All these streams are probably only the higher branches of a river which passed out of the ancient Weald somewhere on the south-east of Beachy Head; the *fifth* of the southern rivers. We may, for convenience, term this the *Ashburn River*.

There appear to be no deposits of gravel belonging to any of these streams. Sir Roderick Murchison has the following

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* At this farm a hammer-post belonging to one of the old Wealden Ironworks is still standing (*see* p. 332).

† *Quart. Journ. Geol. Soc.*, vol. vii. p. 360.

note.* "At East Bourn, where the . . . . drift consists chiefly of clay and loam, a harvest of fossil mammalia has been for many years obtained, and from it DR. MANTELL has already cited *Elephas primigenius, Hippopotamus, Cervus, &c.*"

The REV. E. S. DEWICK informs me that the Elephant molar (which, with the other fossils referred to, is in the collection of the late MR. CALDECOTT of Eastbourn) seems to have been imbedded in a calcareous rubble. It is said to have been found at Southbourn, 8 feet from the surface. MR. DEWICK considers that the deposit is probably of subaërial origin, and he thinks it possible that the Hippopotamus tusk may have been labelled in mistake.

A rather curious section was exposed in February 1868 just west and south-west of Polegate Station, showing stiff clayey wash, almost like shale in places, but containing chalk flints, 8 feet thick in one place. This overlies Lower Greensand.

Near the coast south of Bexhill there is a covering of loam over the flat. Some of the valleys at Hastings contain loam on their sides and lower slopes.

These deposits are probably in great part simply rainwash, but some may have been deposited by streams. "In a diluvial clay, or loam, in a valley near Hastings, a tooth of the Asiatic elephant has been discovered." †

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* *Quart. Journ. Geol. Soc.*, vol. vii. p. 355.
† DR. MANTELL, *South-east of England*, p. 43.

CHAPTER XIII.—RECENT DEPOSITS.

In this chapter we will describe the various accumulations of recent date. They may conveniently be classified as follows:—

Alluvium and peat.
Submarine forests.
Blown sand.
Shingle.

This arrangement shows the order in which they can best be described, but not their relative age. Possibly if arranged for such a purpose the submerged forests should go lowest, and the others be bracketed together as of equal age; all in fact are being formed now, "submerged forests" included, under certain circumstances.

Alluvium.—This occurs fringing all the larger streams; its breadth is by no means proportionate to the size of the stream, but rather to the *fall* of the stream. The smaller the fall the wider the Alluvium. It occurs also in two large areas on the coast, Romney Marsh and Pevensey Level.

I extract the following account of the Alluvium of Romney Marsh from MR. DREW's Memoir on Sheet 4, Geological Survey, 1864:—

"In giving an account of Romney Marsh it will be necessary to go somewhat beyond the bounds of the present sheet, and beyond Romney Marsh proper,* following the arms or inlets of it up the course of the River Rother to Small Hithe and Bodiam, along the smaller streams that flow by Winchelsea, and to the most south-westerly point of the Marsh at Cliff End near Fairlight. These places are contained in Sheet 5 of the Ordnance Map

"It will be seen that the whole area is either coloured on the map as Alluvium or Blown Sand, or is marked as Shingle Beach. The whole of the Alluvium is below the level of high water at spring tides, but the access of the sea is prevented by tracts of shingle bordering the Marsh, which are partly piled above the level of high water, and by artificial walls which have been erected where no natural barrier of shingle exists. The patches of Blown Sand consist of irregular hillocks, generally less than 20 feet high.

"The soil of the Alluvium is generally clayey at top, but it is sometimes peaty (or moory, as it is called), and now and then

* "The name of Romney Marsh should perhaps properly be restricted to that part of the level which is on the north of the Ree Wall, along which the road goes from Appledore to Romney, the rest bearing the different names of Walland [or Walling], Dunge, and Guildford Marshes; but in common language the whole is called Romney Marsh. Certain other parts are called the Dowls on the north-east of Appledore, Shirley Moor which lies between Ebony and Woodchurch, Wittersham Level along the banks of the Rother, Pett Level south of Winchelsea, &c."

sandy. The clay soil is not so stiff nor so cold as many clays; it is not difficult to till, and yields heavy crops of corn year after year without requiring any dressing. By far the greater part of the Marsh, however, is in pasture, feeding sheep and cattle in a large proportion to the acreage. There are no hedges in the Marsh, but the land is divided by means of ditches or dykes, which carry off the water into certain chief water-courses that lead to the shore, and drain into the sea at places called "Guts." The chief of these are Jews Gut, Dunge Marsh Gut, and Globsden Gut. At each gut there is a sluice which allows egress to the fresh water at low tide, and prevents the access of the sea when it rises. By these means the flat is kept dry and free from floods, with the exception of one part called Appledore Dowls which lies on the north of the road from Appledore to Snargate. This is the lowest part of the Marsh, and the water that falls on it is pumped up by steam into the Military Canal, but in spite of this the land is always flooded in wet seasons.

"I will now proceed to describe the soils that are met with beneath the surface. The peat seems to occur mostly at the Dowls, and from there towards Ivychurch and Hope, but there is some in Dunge Marsh and Walland Marsh, and it often occurs in the marshes at the side of the Rother and its tributaries far inland. By the side of the railway on the north of Appledore station there are some pits, generally full of water, but where, after a long continuance of dry weather, peat and clay may be seen, with trunks of trees or moor-logs. The wood, which is oak, is black, and has a charred look outside, but it cuts smoothly with a knife, and would take a polish, being pretty hard and tough. The stumps of several trees seen here look as if they had grown on the spot. In other places I hear Alders and Hazel have been found in the peat, and nuts occur very frequently. When peat is at the surface there is generally clay below, at a depth of five or six feet perhaps. Clay also sometimes occurs overlying the peat. Along the shore for some distance above Leeds Gut, and opposite Holme Stone, as well as further east, there is seen below the shingle at about mean water level some hard peaty mud or clay, which is now being wasted by the sea. This fact has some bearing on a question that will be discussed further on. Sometimes in clearing the dykes the workmen come upon a layer of beach pebbles, not of any great width, a bar of shingle in fact. The lighter soil (sand being near the surface) occurs in patches about Broomhill and [East] Guildford, and in many other parts, even for a long way up the valley of the Rother at Newenden, &c. Whatever the soil may be near the surface, it is almost invariably the case that at a depth of 10 or 20 feet, there is loose sand, often containing recent marine shells, especially cockles. The bottom of this is seldom reached in any well-sinking, and its thickness is not known. Mr. Elliott tells me he bored 70 feet in the Marsh, of which the last 50 were in sand."

Pevensey Level, the second great alluvial area, is of much smaller extent than Romney Marsh. It is wholly fringed by

shingle, so that no sea-walls or other artificial defences are necessary. The alluvium extends up the country to the north-east; in a broad flat as far as Boreham Bridge, and in much narrower strips beyond that place. There are three well marked islands of Weald Clay and Hastings Beds rising through the alluvium; these are Horse Eye, Rock House Bank, and Chilley Green. The alluvium of this district seems very much to resemble that of Romney Marsh, but it has not been so well explored.

Bourn Level is a smaller alluvial flat separated from Pevensey Level by the rising ground upon which Langley Farm is built.

The general section of the alluvial deposits here, as exposed in the excavations for the new Baths, is as follows * :—

	Ft.	In.
1. Black vegetable soil - - - - -	3	0
2. White calcareous marl, consisting of wash from the Chalk; containing land and freshwater shells; and at its base the bones of *Cervus Bos*, &c. - -	4	0
3. Black vegetable matter, with trees, hazel nuts, &c., and a few land and freshwater shells - - -	2	0
4. Blue clay; passing below into true Gault clay with fossils - - - - - - - -		

Near Hornsey Farm the clay above the peat is not marly.

Still further to the east, near the Archery Tavern, 6 feet of sandy clay rest on a loose sea-sand, some 14 feet of which were passed through in a well close by.

In Pevensey Level the succession is :—

1. Soil.
2. Clay with freshwater shells.
3. Clay with *Scrobicularia, Cardium*, &c.
4. Peat with trees.
5. Clay.

Dr. Mantell states that the blue clay between the peat in Pevensey Level contains marine shells.†

There is very little worthy of note in the modern Alluvia of the rivers. That of the Teise is wide and very much subject to floods; so also is that of the Medway near Snodland, where there is another wide spread. There is a good deal of Peat in the Alluvium north of Leybourn, south of the two small islands of Folkestone Beds; and again towards Horn Street. It is at least 6 feet thick in the southern part, and may be more.

The Peat near Wye on the Stour has already been mentioned (p. 171), it has not been mapped as alluvium.

At Isfield, on the River Ouse, near Uckfield, a great thickness of peat was passed through in making a well near the paper mills. Dr. Mantell ‡ says there was nearly 20 feet of it.

Accumulations of peaty matter are often found over the more extensive sandy beds. They are of most importance over the

* Rev. E. S. Dewick, on "The Alluvial Beds of the Wish;" read at the Eastbourne Nat. Hist. Soc., and published in the *Eastbourne Gazette*, May 28, 1873.

† Geology of the South-east of England, p. 19.

‡ Ibid, p. 19.

Lower Greensand area of Surrey and Hants, and chiefly so upon the sands of the Folkestone Beds.

"A considerable bed has lately been worked in a meadow belonging to Shoeland Farm, in the parish of Puttenham, near the foot of the south side of these [North] Downs; some in Thursley and Witley, a little in Shere, Abinger, Wotton, and Reigate."*

"In the bottoms [of Woolmer Forest], where the waters stagnate, are many bogs, which formerly abounded with subterraneous trees. . . . . I have seen cottages on the verge of this wild district, whose timbers consisted of black hard wood, looking like oak, which the owners assured me they procured from the bogs by probing the soil with spits, or some such instruments, but the peat is so much cut out, and the moors have been so well examined, that none has been found of late. Besides the oak, I have also been shown pieces of fossil wood, of a paler colour, and softer nature, which the inhabitants called fir; but upon a nice examination, and trial by fire, I could discover nothing resinous in them, and therefore rather suppose that they were parts of a willow, or alder, or some such aquatic tree.

"Old people have assured me, that on a winter's morning they have discovered these trees, in the bogs, by the hoar frost, which lay longer over the space where they were concealed, than on the surrounding morass."†

In the lower parts of Ashdown Forest there are peaty areas out of which large trees have been dug. These are chiefly Oak, but sometimes Fir occurs.‡

Submarine Forests.—Under this term are included all accumulations of peaty matter with remains of trees occurring below high-water mark. Their occurrence under such circumstances is generally taken to prove a depression of the land, perhaps in some cases without sufficient reason.

Peat, or old forest growths, round the south-eastern coasts, are generally found at the mouths of valleys, or opposite wide alluvial tracts; none occur along the foreshore beneath cliffs. Where the bottom of the peat is reached by digging, or is exposed on the shore, there is generally found a soapy clay, in which the roots of the trees are embedded, proving this clay to have been the soil on which the trees grew. In other places where trees are absent there is no reason to doubt that the peat or peaty mud was formed in its present position.

The peat with trees in Romney Marsh has already been noticed, and also the peat which occurs on the western shores of the Marsh. Proceeding westwards we note the following places.

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* MANNING and BRAY, *History of Surrey*, vol. iii. appendix, p. lxx. 1814.

† WHITE, *Nat. Hist. of Selborne*, letter vi. 1789. MR. G. H. KINAHAN informs me that the trees in the Irish peat bogs are discovered in this manner.

‡ Rev. E. TURNER on "Ashdown Forest," *Suss. Arch. Coll.*, vol. xiv. p. 39. From the absence of *Ash* trees in these old forest growths, and their comparative scarcity now in the district, MR. TURNER infers that the name of the forest has not been derived from the Ash, as is generally supposed.

There is a good deal of wood beneath the alluvium of Pett Level, and it occurs on the shore opposite here.

At Hastings the submarine forests have long been known and have often been described. That opposite Carlisle Parade has been dug into to a depth of 6 feet; it consists of peaty earth enclosing wood, leaves, hazle-nuts and acorns; stags' horns have also been found here. The wood is chiefly oak; this is always black, but is generally strong enough to be worked into ornaments. A lighter coloured wood is found in smaller quantity, which has suffered much less change than the oak. This forest extends up the Priory valley, the lower part of which until quite recent times was covered by the sea.*

Further to the west, nearly opposite the middle of Eversfield Place, there is a little peaty mud with wood, occasionally seen at very low tides. This probably belongs to the valley which opens at Warrior Square.

Opposite the levels at Bulverhithe a forest was traced by SIR WOODBINE PARISH, at low water, "from the western extremities of St. Leonard's to the headland at Bulverhithe." In the peat were found "hazel-nuts, a variety of seeds, and the remains of beetles and other insects."†

Passing westwards along the line of low cliffs by Bexhill, where the submarine forest growths appear to be absent, we find them again opposite the western end of Pevensey Level. "In this place there are the remains of 200 or more trees, which are firmly rooted to the soil, now become sand, and still retain their perpendicularity, and original position. Some of the trees are four or five feet above the surface; others have been cut down, or rather, I conjecture, worn away by the continued flux and reflux of the water. The ramifications, &c. of the roots are very perfect. The trees are . . . . . principally oak and birch. At high water this spot is covered by the sea to the depth of ten or twelve feet."‡

It is generally supposed that the occurrence of "submarine forests," along the coast *necessarily* proves a subsidence of the land. The fallacy of this reasoning was long since pointed out by the late REV. J. YATES in the following description of a submarine Forest in Cardigan Bay:—"It is bounded on the land side by a sandy beach and a wall of shingles. Beyond this wall is a tract of bog and marsh formed by streams of water, which are partially discharged by oozing through the sand and shingles. The author argues that, as the position of the wall is liable to change, it may have inclosed the part which is now submarine, and that it is not necessary to suppose a subsidence effected by subterranean agency."§

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* See a map of Hastings dated 1746, published by MR. ROSS, in *Suss. Arch. Col.*, vol. xii.

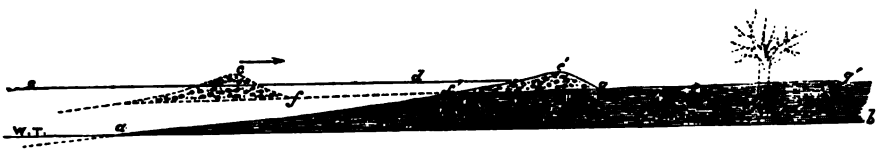
† *Proc. Geol. Soc.*, vol. ii. p. 3 (1822).

‡ *Gentleman's Magazine*, 1814, vol. lxxxiv. pt. ii., p. 128.

§ *Proc. Geol. Soc.*, vol. i. p. 407, 1832. See also MURCHISON'S *Silurian System*, p. 563, 1839; GODWIN-AUSTEN, *Quart. Journ. Geol. Soc.*, vol. xiii. pp. 41, 60, 1857; and COL. GREENWOOD'S *Rain and Rivers*, 2nd ed., p. 123, 1866.

I have represented this process in the following diagram (fig. 35).

Fig. 35. Diagram to illustrate the formation of "Submarine Forests."



a. b. Low-water mark. *e.* Old position of beach.
c. d. High-water mark. *e'.* Present „
f f' g g'. Extent of old marsh. *g g'.* Extent of present marsh.
f'. Submarine forest.

The shells which occur beneath estuarine alluvium lend some countenance to this explanation.

In Lewes Levels the section of alluvium is as follows*:—

1. Vegetable mould.
2. Peat: a mass of decayed vegetable matter, with leaves, and occasionally trunks of trees; from three to five feet thick.
3. Dark blue clay, provincially termed *silt*, containing fresh-water shells in the upper part, and an intermixture of sand and marine shells in the lower ["the intermediate layers containing an intermixture of both"]; from five to 25 feet.
4. Pipe clay; the detritus of the chalk-marl basin, in which the preceding beds are deposited; from one to four feet.

In this case the silt with marine shells would represent an old condition of the valley when it was constantly, or at every tide, covered by the sea; subsequently a bar of shingle, extending across the mouth, blocked the fresh water in and the salt water out; the gradual change from salt to fresh water conditions being here distinctly marked. Within this fresh-water swamp the forest grew.

At Wissant, north of Boulogne, there is a submerged forest; here too it is opposite a stream valley. Mr. Day states that a bone (? *Bison priscus*) found here contains sand with *Planorbis* and *Bithynia tentaculata*.†

I do not of course wish to deny that subsidence of the land has occurred, or that forest-growths do not extend below low-water mark. On the west and south-west coast they certainly do extend for some considerable distance below low water, and this can only be explained by subsidence.

The submarine forests of the south-east of England have as yet yielded no remains of the Beech. Hazel-nuts are very abundant, acorns also occur, but no beech-nuts. There are a few cases on

* Mantell, *South-east of England*, p. 16.

† *Geol. Mag.*, vol. iii. p. 112. I cannot agree with my friend, Mr. Day, that the deposit of flints at the mouth of the valley here is in any sense a "raised beach." Mr. Whitaker and myself examined it together, and to us it appeared only a stream deposit of angular flints cut into section by the coast line.

record in which Beech has been mentioned as occurring in such forests. This is a point of considerable interest, and although the localities are not within our district I give the authorities in a note below.* It would be important to have these observations verified, as it is doubted by many whether the Beech be truly a native of Britain.

Blown Sand.—The Wealden coast is singularly bare of blown sand as compared with the opposite coast of the Boulonnais. On the other hand we have great shingle beaches, whilst on the French coast there is but little shingle.

There are three small patches of blown sand near the shore of Pevensey Level (shown on Sheet 5). These are low hills and are of no importance. They lie on the left bank of the River Ashburn, and close to its mouth.

In Romney Marsh there is more sand, occurring chiefly in two places: on the eastern side of the present mouth of the Rother, in Guildford Level; and at the Warren, on the eastern side of the old mouth of the Rother, near Romney. The sand does not cover any great area, nor does it rise to any great height. It lies in low irregular hills, generally less than 20 feet high. There is another small patch just north of Butter's Bridge, near West Hythe, which is interesting from the fact that there is some reason to believe it existed here in the 9th century. If so, and if the Rother (Limen) ever flowed along the north side of Romney Marsh, as many antiquaries believe, then this patch would have been on the north side of that river. Therefore on the left bank of each mouth of the Rother there was, or is, blown sand; whilst, as we shall presently see, on the right bank of each mouth there was or is shingle.

MR. MACKESON pointed out to me a little blown sand which occurs on the top of a quarry just above Hythe Church, on the west side of the road. I have not the height of this spot above the sea, but it is probably not less than 150 feet. This is an unusual height for blown sand along this coast, but on the coast of France and in the south-west of England it often occurs at even greater heights than this.

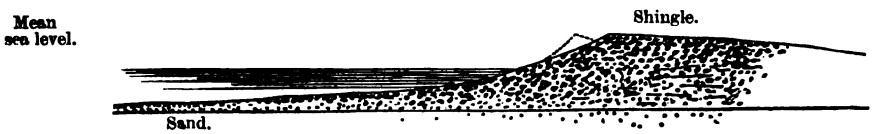
Shingle.—Nearly the whole of the Wealden coast is furnished with a fringe of shingle more or less wide; the wider areas are shown on the maps by stippling. The pebbles forming this shingle are almost entirely of chalk flints. They are for the most part well rounded; not so thoroughly worn as those of the remarkable pebble-beds of the Lower London Tertiaries, but far more so than those of river gravels, or of the gravels which cover the flat lands near Chichester, and which are no doubt of marine origin.

* At Bournemouth in a peat bog; Rev. W. B. CLARK, *Proc. Geol. Soc.*, vol. ii. p. 599, and *Brit. Assoc. Rep.* for 1837, p. 94. Near Shrewsbury, in peat below gravel which contains marine shells; TRIMMER, *Proc. Geol. Soc.*, vol. ii. p. 200. At Swansea in peat; M. MOGGRIDGE, *Quart. Journ. Geol. Soc.*, vol. xii. p. 169. On the shores of Lancashire; C. E. DE RANCE, *Quart. Journ. Geol. Soc.*, vol. xxvi. p. 665. DE LA PRIME, in his "Letter concerning Trees found under Ground in Hatfield Chase" (*Phil. Trans.*, vol. xxii. p. 940, 1701), says that Beech has been found there. MR. PENGELLY informs me that Beech-nuts occur in the submerged forest of Blackpool, near Torquay.

MR. DREW'S description of the Shingle of Romney Marsh is as follows:—

"The beach or shingle occupies so great an area, extending over thousands of acres, and occurring for miles inland as well as along the shore, that it deserves particular attention, and as there are some things to be noted in it that throw light on the order and time of the accumulation of these recent deposits, it will be well first to describe the way in which shingle is now moved and re-arranged by the waves on the present shore, and then the past changes will be better understood. The form of a shingle beach exposed at low water is generally somewhat like that drawn in the diagram (fig. 3). The summit is a few feet above the level of

Fig. 36. Diagram-section of a Shingle Beach.



high water at spring tides, while the foot of the shingle is usually a few feet above low-water mark, so the vertical height on this shore is somewhere about 18 feet. Now when the waves break, supposing their direction to be at right angles to the coast line, they run up the slope, and carry pebbles with them, and on returning they partly draw them back; but the force of the breaking wave being greater than that of the return current (undertow) the beach is gradually 'fulled,' that is, pebbles are heaped up in front of the breaker, generally forming a small ridge. This is shown by the dotted line in the diagram. As the tide rises or falls the level at which the action takes place changes, so that the result varies very much in different states of the weather, and according to the force of the waves at different times of the tide, and thus it often happens that what is done in one tide is undone during another.

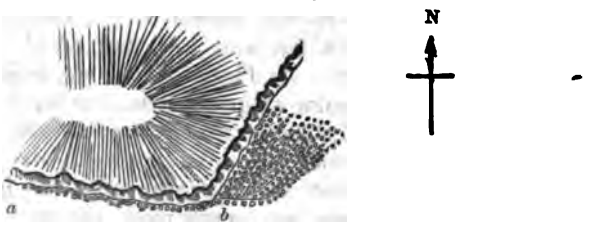
"The waves striking directly against the shore do not, however, produce so great an effect as those which come obliquely, for these wash the pebbles up diagonally, and on breaking still run along the shore, carrying the pebbles with them, thus both piling up the shingle and producing a general lateral movement of the stones from windward to leeward.

"If the wind changes so as to make the waves strike obliquely to the shore the other way, the shingle will of course travel in the opposite direction; but in the course of time it will have travelled in a direction determined by the prevalent winds. The average result is that, under favourable circumstances, a rounded shingle bank is formed, rising as high as the highest breaking waves can reach during gales in spring tides, the greatest slope of the shingle being generally seaward near the crest of the bank.

"On this coast the south-west wind is by far the most prevalent, and the waves consequently strike on the shore in such a way as to give the shingle a movement from west to east, for the effect

of the S.W. winds greatly overbalances any motion in an opposite direction brought about by easterly or south-easterly winds. It follows, therefore, that the shingle about Romney Marsh was derived from rocks that occur to the westward, being formed of flints that come directly or indirectly from the chalk of Sussex, and other areas further west. If the shingle as it travels along meets with an obstruction, such as a jetty, pier, or one of those 'groynes,' * so frequent on parts of this coast, it is stopped, and accumulates on the weather side, protecting the land from the wasting action of the sea. A change of wind will, however, occasionally sweep away for a time nearly all the shingle that had accumulated. In front of Sandgate, and from there to near Folkestone, some of these groynes can be seen.

Fig. 37. Diagram to illustrate the Formation of a Shingle Beach round a Promontory.



"Another cause of accumulation of a breadth of shingle is the following:—If *a*, *b*, *c*, (fig. 37) be a promontory, and *a*, *b*, the shingle travelling eastward, when the pebbles reach the point *b* they will generally keep to the shore, and turning round go some way along the face *b c*; but here they are more or less sheltered from the action of the waves, and in spite of the occasional action of non-prevalent winds, the result would be a great supply of shingle at the point *b*, piled up in a succession of 'fulls' or ridges, as shown in the figure. The same effect would be produced if the necessary form of the coast were brought about by artificial means, and one or two illustrations of this occur in the present district, to be explained further on.† It is to the above-described process, continued through a long course of time, that the wide tracts of shingle at the edge of the Marsh owe their formation. On the west they begin at Cliff End, three miles south-west of the old pier head, south of Rye. All along these three miles of coast there is a high straight bank of shingle running N.E., and forming the present beach, which is only overflowed when a high tide happens to be accompanied by a heavy sea. Within it is a strip of shingle about 200 yards broad, some feet

* "Groynes" are wooden barriers crossing the line of beach, generally at right angles to its course, which are intended to arrest the shingle, and thus prevent the waste of the coast. They were formerly called "knocks." (ELLIOTT, *Proc. Inst. Civ. Eng.*, vol. vi. p. 470).

† For further information about the movements of shingle beaches, see PALMER "On the Motions of Shingle Beaches," *Phil. Trans.*, vol. CXXV. p. 567; and REDMAN "On the Changes of the South Coast of England," *Proc. Inst. Civ. Eng.*, vol. xi.

lower than the present beach. The old lines of shore are plainly visible, trending away from the present one at an angle of about 45° in a northerly direction. They are expressed by the lines on the map.* Further inland lies the marsh-land at a still lower level. South and south-east of Rye the shingle is irregularly mingled with the Alluvium, but even when covered with turf, as it is in some places, the ridges can be traced out, and have been added by myself to the Ordnance Map as well as the one-inch scale would allow. In reality, however, they are far more numerous than I have drawn them, being not more than 20 or 30 yards apart. Further east, around where *Midrips* is marked, the shingle is very flat, and the ridges can hardly be traced. The country is there about six feet lower than the outermost 'full' that runs nearly at right angles to them. Holme Stone is almost bare shingle, with here and there a few stunted holly bushes, trimmed by the wind to a regular slope on the south-west, while on the shingle generally deep-rooted bushes of blackthorn appear from one shoot, spreading out flat and low, and often not rising six inches above the ground. At Holme Stone the beach is arranged in very straight and regular ridges, continuing for a length of two miles and more inland; they are, however, seldom more, and sometimes less, than a foot above the troughs, and are about 40 yards apart. They are at a lower level than the present beach. In some places the lines are made more distinct by thin grass growing on the smaller shingle which here forms the top of the ridges, and not on the larger stones which are found in the troughs. In other places the ridges can only be distinguished by differences of colour, due to certain lichens which grow chiefly on the larger stones, and thus produces a tint which contrasts plainly with the brownish hue of the smaller pebbles. Lydd Ripe, on the south of the town, is shingle, overgrown with grass, and the ridges are very distinct; and north of the town the shingle, though covered by blown sand, may still in places be traced beneath it by the ridged form of the ground, the lines of which follow the same general direction as those on the south of the town, being nearly parallel to the roads.

"Dunge Beach is the widest spread of shingle in this area, being three miles long and from one to three miles wide, in some parts absolutely bare of vegetation for hundreds of acres, and in others sparingly dotted with furze bushes and broom. Roads there are none, only a few tracks, and it is altogether a most desolate-looking place. Those who have to cross the shingle usually put on a pair of 'baxters,' or small flat pieces of wood with a leathern loop for the foot. They are used with a peculiar sliding gait, and make the walking much more easy. The 'shingle-fulls' here run in various directions, and they vary also in height; those about Wigmore Pit are seven feet lower than the modern one which runs straight along shore, and may be taken as a standard, as it is nearly of the same height all along. A little east of the words

* Sheet 5, Geological Survey Map.

Abnor Pit the 'fulls' gradually get higher as you go south, and about Dunge Marsh Gut and the Lighthouse the inner 'fulls' are only a foot or so lower than the outermost, while all those for a mile inland from the shore between Dunge Ness and Great Stone are at a high level. There is not much to remark about the shingle near Romney, it is so much covered either by the buildings of the town, or by blown sand. Along the shore by Dymchurch the shingle no longer accumulates now that the groynes have been removed, and a stone wall built in their stead. Near Hythe there is another tract of shingle, three or four miles long and half a mile wide; the ridges curve in various directions, they are about 30 yards apart, and are two feet or so above the troughs. From the Sluice House to Folkestone there is only a narrow beach of one ridge, but at the latter place there is some accumulation of it which will be spoken of later." (See Chap. xvii.)

The shingle of Langley Point is of far less extent than that of Dunge Ness. The old fulls have a general northerly trend and are cut off abruptly by the modern full on the west of the point; but to the north-east of the point they gradually approximate in direction to the modern full. On the west of Crumble Pond the fulls are very indistinctly marked, and there I did not attempt to map them.

PART III.

PHYSICAL GEOLOGY.

CHAPTER XIV.—STRUCTURE OF THE COUNTRY.*

Many of the facts related in the following pages have been long known to geologists, chiefly through the labours of MARTIN, FITTON, and HOPKINS. It may suffice here to refer to the titles of their papers bearing upon this subject, which will be found in Appendix I., under the following years:— MARTIN, 1827–9, 1841, 1851, 1854, 1856–7; FITTON, 1836; HOPKINS, 1845.

I cannot, however, enter upon this subject without referring more particularly to the paper of MR. HOPKINS, "On the "Geological Structure of the Wealden District and of the Bas Boulonnais." Trans. Geol. Soc., Ser. 2, Vol. VII., p. 1 (read in February 1841, but not published till 1845). This memoir displays an immense amount of labour in the field, for a great part of the Hastings Beds area was until then quite unknown. The descriptions which MR. HOPKINS gives of the longitudinal folds are minute and, with few exceptions, exact. Probably many of his "transverse fractures" are imaginary. The points, however, upon which my colleagues and I differ from MR. HOPKINS are perhaps less in matters of fact than in the conclusions which he draws from those facts.

The Wealden area, viewed as a whole and including the Bas Boulonnais, may be regarded as a great anticlinal, or rather as a truncated dome with a quâquâversal† dip, swelling up from beneath higher beds on all sides. In this anticlinal area the lowest beds occupy the centre and dip all round under superior beds. But in studying the country in detail we soon discover that, although the foregoing statement is generally true, the structure is less simple than is there expressed, and that there are a number of minor folds traversing the district in lines more or less parallel to its general axis of elevation.‡ The most important of these will be now described.

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* The sections in this chapter (excepting figs. 40, 44, 47, 49) are drawn to an uniform scale of 1 inch to 1 mile horizontal, and about 2 inches to 1 mile vertical; the vertical scale is therefore only slightly exaggerated (as 2 : 1). In fig. 40 the exaggeration is somewhat greater; and in fig. 49 it is considerable (as 10 : 1), this being only a diagrammatic section. Figs. 44 and 47 are drawn to a true scale.

† The term *periclinal*, used by DR. PAGE (Text Books on Geology), is much better than this.

‡ As regards the general line of elevation of the Weald, see the remarks at the end of this Chapter.

Before doing this, however, it may be well to state the actual amount of elevation at various points along the central line. If we suppose the whole amount of strata removed by denudation to be restored to its original position, and the dome of Chalk to extend unbroken over the whole area, we should have the following approximate heights to the base of the Tertiaries* at different places, commencing on the west and passing east:—

		Feet.
Weald.	Selbourne	1,000
	Harting Combe (Hindhead and Leith Hill perhaps about the same)	2,000
	Horsham	2,200
	Turners Hill	2,600
	Crowborough Beacon	3,000
	Poundsford	2,800
	Fairlight	2,400
Lower Boulonnais.	Mont Lambert, near Boulogne	1,400
	Tellingen, about 5 miles E.N.E. of Desvres	800

Such assumed heights as these have been termed by MR. HOPKINS the *geological elevations* of the district, as distinguished from the actual elevation of its existing surface.†

It will be well to adopt the method of description hitherto employed, and take the central country first; but it will not be necessary to adhere strictly to the plan of describing everything from east to west.

Ore and Fairlight.—The central line of elevation is well seen on the coast at Fairlight. Its general characters have already been mentioned (pp. 45 and 116), and are further illustrated in Figs. 38 and 39.

The anticlinal line coincides pretty closely with the high road which runs from Fairlight through Ore towards Battle. The dip is, as a rule, greater on the north side than on the south.

On the south of Ore and Fairlight the beds dip south until we reach the line of fault, which throws to the south and runs east and west on the south of the Fish Ponds. Here there is a tendency to a synclinal arrangement. Further west, on the south-west of Hollington the beds are very much disturbed and faulted. Some of these faults are seen in section, others are inferred. Through the southern part of Hastings, and westwards by Bohemia, the dip is to the south, but on the south of St. Leonard's the beds rise again and dip north. There are, thus, besides the rolls shown in Fig. 38, two others of less importance to the south, which along this line are hidden by the sea. On the north of the Fairlight ridge there appears to be a slight synclinal fold, beyond which the dip is regular, and generally small, to the north.

* The question whether or not the Chalk over the centre of the Weald was denuded before the deposition of the Eocene Beds, is of no consequence here. The object of this table is merely to express the relative amount of upheaval at different points, which can, perhaps, be most conveniently done in this manner.

† *Loc. cit.*, p. 34.

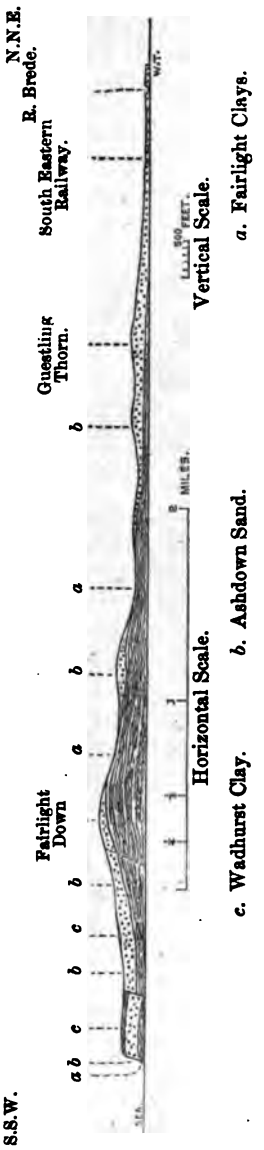


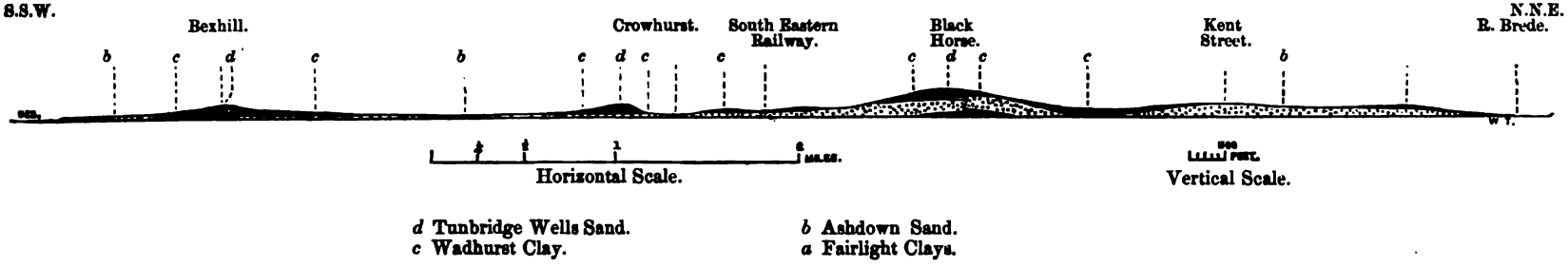
Fig. 38. Section from the Sea east of Ecclesbourne to the River Brede near Udymer through the central part of the Fairlight Anticlinal.

The summit of Fairlight Down is 576 feet. The ridge falls slightly to the east, being perhaps near 400 feet * at the Black Horse. On the north of the anticlinal there are the following heights:—Guestling Church, 170 feet; Guestling Thorn, 178 feet; Icklesham Church, 148 feet. On the south of the anticlinal we have the following points along the coast:—Lovers Seat, 340 feet; East Cliff, Hastings, 247 feet; Hastings Castle, 261 feet.

Fig. 39 is taken through the western end of the Ore ridge, just east of the Battle "pass." Here the southerly dip is much more

* From a doubtful aneroid observation.

Fig. 39. Section from the Sea near Bexhill to the River Brede near Sedlescombe, through the western part of the Fairlight Anticlinal.



regular than in the line of section just described. The beds about Ninfield, Sidley Green, &c., are as a rule tolerably flat. The fault drawn north of Bexhill runs very nearly parallel to the anticlinal line. It throws to the south but not to any great amount. On the south of this the beds dip to the north at a slight angle but soon roll over again.

This country is dotted over with patches of Tunbridge Wells Sands, the valleys are all in Wadhurst Clay. The height of Bexhill Church is 154 feet; from this to 100 feet is about the height of the summits of this district.

On the north of the Ore ridge there is a synclinal, which is perhaps a continuation of that, of which there is some evidence, on the north of Fairlight; but the intermediate country is obscure, and disturbed by faults.

Brightling Line.—This, as far as the general structure of the country is concerned, must be regarded as the prolongation of that of Ore and Fairlight, but there is no evidence of their running into each other.

The anticlinal runs from near Archer Wood, where (the beds being much faulted and disturbed) it is not definitely marked,* westwards through Limekiln Wood, Darvel Wood, Brightling, and Glaziers Forge. The whole exposure of the Purbeck Beds lies along or to the north of this line.

Mr. Hopkins has some notes on small and local rolls between Battle and John's Cross.†

Brightling Down (636 feet) is the highest point in this part of the Weald. Other summits on the west are Blackheath Mill, and the high ground near Cross-in-hand. The anticlinal runs along the north of this ridge, as far, perhaps, as Cross-in-hand. From the north of Heathfield Park another ridge runs eastwards towards Burwash, this is on the northern side of the great anticlinal and, apparently, does not coincide with any line of elevation. Between this ridge and that before mentioned as running from Brightling westwards, there is the deep wooded valley in which the chief exposure of the Purbeck Beds occurs. It runs in an easterly and east-north-easterly direction from Heathfield Park, and joins the valley of the Rother at Etchingham. To the east of Cross-in-hand the streams run in a general westerly direction into the Ouse. Those on the north run a little east of north into the main branch of the Rother, which runs from west to east. Those on the south run in a general southerly direction into the Cuckmere.

The ground, thus furrowed by valleys, has, as a whole, a general slope to the north and south. The southern slope falls at an angle of about 2°. The dip of the rocks is more than this, and thus higher beds come on at lower levels. This is an excellent example of a "dip slope," whilst on the north of Dallington Forest

* At the spot in Archer Wood, when it was proposed to put down the "Sub-Wealden Boring," the beds were found to be dipping to the south at an angle of 50° or 60°.

† *Loc. cit.*, p. 3.

the fall of ground into the valley of the Purbecks is a "denudation slope" solely. To the north of the ridge from Cross-in-hand to Burwash the dip slope is again seen.

The whole area occupied by the Purbeck Beds is much obscured by faults, many of them of some magnitude. The following notes, by MR. C. GOULD, relate to the most important in the Brightling district:—

"There is a long fault along the valley running east from Tottingworth with a downthrow to the south. It is well proved at several points, as for instance in Swife, Poundsford, and Westdown Gills, by the Blues on the north side being brought against the Greys on the south. The throw is therefore at least 100 feet near Poundsford, but it lessens towards the east. A north and south fault falling into that just noted and passing through the *h* of *Tottingworth* has been worked up to on the east side.

"At Glazier's Forge a fault with a downthrow south brings the Greys against the Ashdown Sand. This fault increases in throw towards the east, for in Rounden Wood the Blues are brought against the Sands. It is on the north side of this fault in Rounden Wood that the lowest beds known occur within 14 feet of the surface.*

"The beds in Darvel Wood are much faulted. The Blues are seen in the stream south of the *Gr.* of *Hollingrove Gr.*, and strike across to the Sands on the north and south."

The beds around Burwash lie tolerably flat, or have a gentle dip north-east into the synclinal which for a few miles coincides pretty much with the valley of the Rother. This synclinal runs from Withernden Bridge eastwards to Etchingham. Possibly this is the same as one, of which there is some evidence, on the south and south-east of Rotherfield. The shape of the outlier of Tunbridge Wells Sand at Beans Oak and High Town plainly indicates the southerly slope of the beds here, dipping into the synclinal.

The outliers of Tunbridge Wells Sand on the west of Burwash, at Browning's, Winter's and Thatcher's Farms, have, as a whole, a decided northerly dip into the synclinal of the Rother; but they are traversed by some transverse rolls, the axes of which nearly coincide with the crests of the outliers. Whether or not these rolls are prolonged as far north as the synclinal in the Rother valley I cannot say. The slopes of the valley here are much covered by old river-loam, which quite obscures the northern end of the larger outlier (see p. 167).

Ticehurst Line.—The ridge upon which Ticehurst is built is anticlinal, and this line is continued to the east, passing a little north of Hawkhurst. The general structure of this district is shown in fig. 40.

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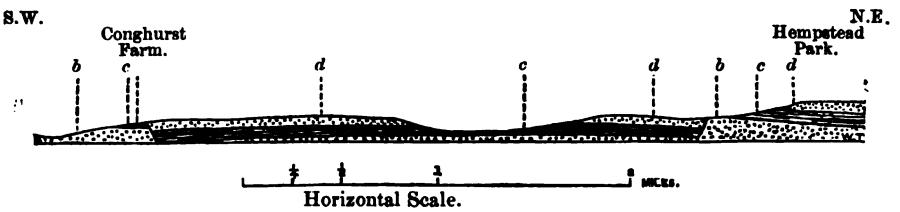
* The exact point is at the south end of the field which lies due east of the word *Rounden* and south of the *y* of *Perrymans*.

Fig. 40. *Section east of Hawkhurst.*



d Tunbridge Wells Sand. *c* Wadhurst Clay.
b Ashdown Sand.

The most northerly fault shown in this section runs for some miles in a general north-easterly direction; it has been traced by the red and mottled clay (Grinstead Clay), which is brought against the Ashdown Sand. The long fault which runs east and west on the north of Mayfield was drawn on similar evidence.

On the north of the line of section given above, the beds dip gradually down to the north and the ground falls as gradually in the same direction.

On the west of the Ticehurst anticlinal, there is another line of elevation which runs from just north of Wadhurst westwards to Mark Cross. This line if prolonged to the west would join that of Crowborough. There is no evidence of their junction, although it is not unlikely that they are the same. MR. HOPKINS * makes the Mark Cross and Wadhurst line to join that of Ticehurst and Hawkhurst. I think this is doubtful; if the former continues to the east, it is probably into the Wadhurst Clay inlier on the north-east of Wadhurst. But the structure of the country east of that town is very much complicated by faults, and the line may be prolonged as MR. HOPKINS supposes. The southerly dip of the Mark Cross and Wadhurst anticlinal is the same already spoken of as being north of a synclinal east of Rotherfield. The southerly dip of the Ticehurst anticlinal is the same as that on the north of the Rother Valley synclinal. The juncture of the two synclinal lines, as of the two anticlinals parallel with them, is doubtful.†

Brenchley, Bidborough, &c.—On the north of Cranbrook there is an anticlinal line which brings up some inliers of Wadhurst Clay. It runs a little north of west on the north side of Horsemonden and Brenchley to Bidborough. The inliers are a good deal faulted, and very likely faults accompany this line in its passage through the sands, where they have not been detected.

The anticlinal crosses the Medway near Penshurst (the point where the Eden falls into the Medway), and is prolonged westwards to Beacon Heath. The line here has the same effect as it

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* *Loc. cit.*, p. 8.

† The structure of these rolls, anticlinals, and synclinals, as well as some minor folds are shown in Sheet 78, Horizontal Section, by DR. C. LE NEVE FOSTER.

has near Brenchley in bringing up inliers, but in this case the inliers are Ashdown Sand brought up amongst the Wadhurst Clay. The inliers of this line are also a good deal faulted.

Although these lines of disturbance can be traced for several miles through the country, and are instrumental in bringing up inliers of some size, yet they are of comparatively small importance in determining the great features of the country. Indeed, to speak of their bringing up inliers is probably to use a misleading expression. The inliers are exposed by denudation, chiefly in the valleys, and the anticlinal has merely brought the lower beds up to such a level that the streams, in cutting their way downwards, have in time reached them. This will be seen by referring to fig. 41, which is taken across this anticlinal.

We have therefore no strongly marked natural feature running through this northern part of the Hastings Beds area. The country to the east and south-east of Tunbridge Wells is, in fact, a high table land deeply cut into by valleys.

On the north and north-west of Tunbridge Wells there is a surface feature which corresponds with the structure. The Bidborough ridge nearly coincides with the anticlinal, and this is a very fair feature. On the west of the Medway there is a line of high ground, which runs from Walnut Tree Cross, westwards, by Dry Hill to Beacon Heath. This also nearly coincides with the anticlinal. These ridges, however, though of local prominence, are small and unimportant compared with those attendant upon the anticlinals of the central country: those of Fairlight, Brightling, and Crowborough, which last we will now describe.

Crowborough Line.—On the south-west of Tunbridge Wells the beds rise towards the great anticlinal of Ashdown Forest, and with this rise of strata the ground also rises, until at Crowborough Beacon it attains its greatest height within the Hastings Beds area. This is 803 feet above mean sea-level. The whole of this high land is occupied by Ashdown Sand, the Purbeck Beds not appearing in even the deepest valleys.* The ridge of highest ground goes in a less direct line than does that of the Brightling and Fairlight anticlinals, probably because the dip of the beds is much less. Its line has been traced in describing the watersheds (p. 164).

It has been already said that the Crowborough anticlinal may be prolonged eastwards to join that of Mark Cross and Wadhurst, but if so it diminishes in force eastwards; the heights attained by the beds rapidly diminishing in that direction. From the highest land of Crowborough we see the ground sloping in all directions most rapidly to the north and south, more gently to the east and west. In all directions too as we recede from the highest ground higher beds come on. The anticlinal of Ashdown Forest is in

* The lower part of the Ashdown Sand of this district probably represents the Fairlight Clays of the Coast.

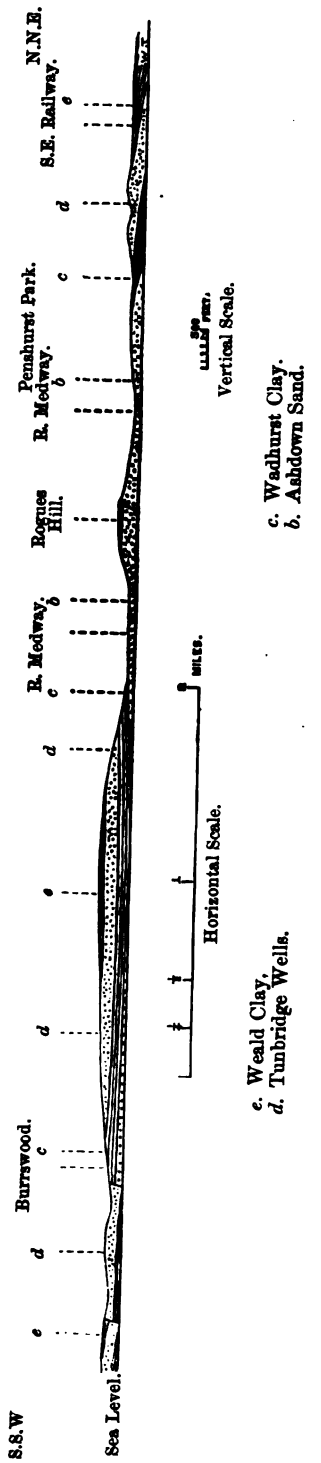


Fig. 41. Section east of Ashurst and Penshurst.
(Reduced from Sheet 77, Hor. Sect., Geol. Survey.)

fact an elongated dome, its beds having the same arrangement as have those of the entire Wealden area when viewed on the large scale.

On the west the Crowborough line is prolonged in diminished force beyond Wytch Cross to the north of West Hoathly. From thence it perhaps goes, by Balcombe Down into St. Leonard's Forest. But in this direction the anticlinal is not well marked, the beds over the greater part of St. Leonard's Forest being exceedingly flat, and, on the outskirts, inclining with very gentle dips to the south-west and north. To the west of Horsham the central line of elevation is probably continued through the comparatively flat area of the Weald Clay into Harting Combe and from thence past Petersfield into the extreme south-western corner of the Weald at East Meon.

On the south of the Crowborough line there are, about Cuckfield, some small folds. The long outlier of Weald Clay lies generally in a synclinal; whilst the higher ground about Cuckfield is slightly anticlinal. This anticlinal is distinctly marked on Hayward's Heath.

We may now pass on to the disturbances which affect the Lower Greensand and Chalk districts, taking first those on the south.

Greenhurst Anticlinal.—A very well-marked line of elevation traverses the Lower Greensand on the south and east of Pulborough, bringing up the Weald Clay within a mile of the Chalk escarpment. It is best seen in the narrow valley of Weald Clay, south of Thakeham, in which Greenhurst Farm stands. The anticlinal traverses nearly the centre of this valley, and gives a sharp dip to the Hythe Beds on the north and south. This line passes west by Wiggonholt Common to Watersfield Common.

To the east of Greenhurst the course of the anticlinal is plainly indicated by the tongue of Weald Clay south of Henfield and Woodmancote. It enters the Chalk to the north of the Devil's Dyke, about west of Piecomb. Here a fault, running parallel with the anticlinal, and with a downthrow south, shifts the outcrops of the whole series a little to the west.

Within the Chalk area the course of the Greenhurst anticlinal has not been carefully traced, but it probably ranges past Standean, Stanmer Park, and along the north side of the Falmer valley, crossing the Ouse just south of Lewes. From thence to the east its course is plainly marked for a few miles. The Chalk at Southerham dips sharply north under the synclinal hill on which Mount Caburn stands, the anticlinal occupying the valley in which the Hastings branch of the Brighton Railway runs. Further to the east its range is shown by a bend in the boundary lines of the rocks, passing through Selmeston into the mass of the Weald Clay to the south of Arlington.

From Arlington eastwards its course is not very clear, there being few sections exposed in the Weald Clay; but in the railway cutting south-east of Stone Cross there is a dip of about 10° to the south-west, and to the north and west of this there is a mass of Wealden sand, on which Pevensey is built, which from its great extent has been considered to be Tunbridge Wells Sand, brought up so near the Lower Greensand by the anticlinal.

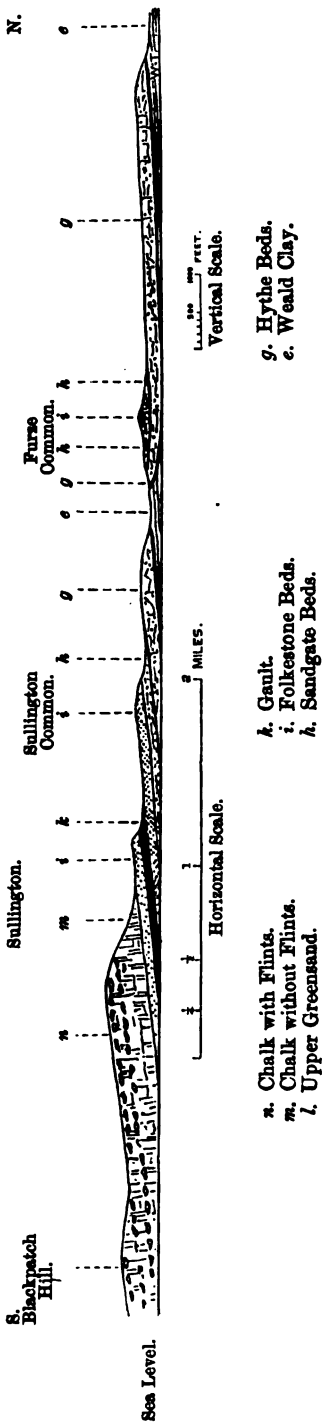
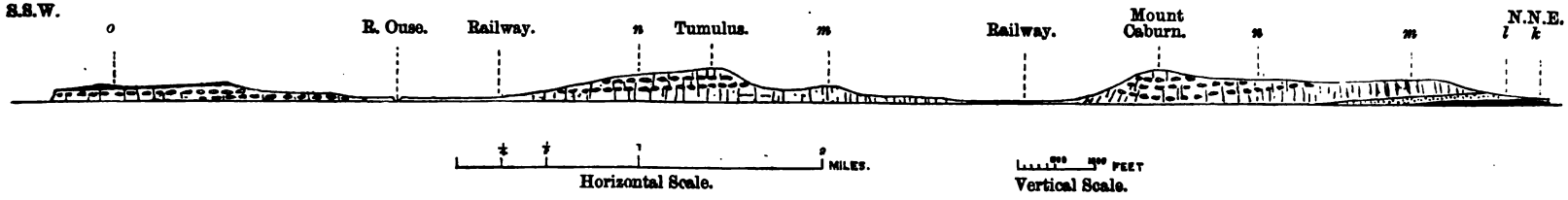


Fig. 42. Section from the Chalk of Blackpatch Hill to the Lower Greensand Escarpment north-east of West Chiltington, through the Greenhurst Anticlinal.

Fig. 43. Section from the Tertiary Outlier, near Newhaven, through Mount Caburn.
(Reduced from Sheet 77, Hor. Sect., Geol. Survey, by H. W. Bristow, F.R.S.)



o. Tertiary Beds.
n. Chalk with Flints.
m. Chalk without Flints.
l. Upper Greensand.
k. Gault.

Henfield and Mount Caburn Synclinal.—To the north of the anticlinal last described, and keeping more or less parallel with it, there is a synclinal fold. The most westerly point at which it is certainly known is at Burton Mill south of Petworth, where there is a small outlier of Gault preserved by the synclinal. This is just opposite to the bend of the Chalk escarpment at which the Greenhurst anticlinal enters the Chalk. The synclinal certainly does not approach the Chalk here, but apparently dies out in the Folkestone Beds about Burton Park. Eastwards it brings in the Gault at Coldwaltham Park, Hardham, and Wiggonholt, and forms the opposing prominences of Lower Greensand at Warminghurst and Henfield; in the roads, about these last-named places many examples of the inward dip may be seen. Still ranging east this line also enters the Chalk, and passing under Wolsonbury Beacon is, like the anticlinal on the south, for a while lost to view, or rather has not been traced. It is well seen under Mount Caburn, and in the prominences of Gault and Lower Greensand south and south-east of Rype. East of this it has not been traced; if it continues through the Weald Clay it is probably to the south of Hailsham, and under Pevensey Level by Horse Eye.

Fig. 42 exhibits the structure of the synclinal and anticlinal folds about four miles east of Pulborough. Fig. 43 the same, near Lewes.

Pulborough and Midhurst Lines.—At Pulborough Mr. Hopkins has described a flexure with a slight bend to the south, which passes westwards by Stopham and Fittleworth.* To the north of this, from Oakhouse Farm westwards by Cicilroy Farm, and to the north of Egdean, there is a slight line of disturbance. It may be the westerly continuation of one or both of these which heaves the beds at Midhurst and Woolbeding.† These disturbances, however, do not alter the lines of outcrop, and are of small importance; that at Midhurst has been disregarded in drawing the Horizontal Section (Sheet 73), for the Lower Greensand beds have, as a whole, only a gentle dip to the south just here.

Beachy Head Lines, &c.—On the shore between Beachy Head and Eastbourn, and again on the north of that town, there are evidences of rolls which are small and unimportant in themselves, but interesting from their being probably the prolongation of those larger rolls which bring in the Tertiary outliers further west, and also the great mass on which Chichester is built.

At Willingdon the top of the Upper Greensand is at some height, probably at least 100 feet, above the sea; at Rodmill Farm it comes down to the Alluvium of Bourn Level. It is carried down thus far by the ordinary dip into the Chalk escarpment. The Upper Greensand, however, rises again over much of the ground on which the new town of Eastbourn is built. Taking

* *Trans. Geol. Soc.*, ser. 2, vol. vii. p. 15. A "flexure" is a roll of the beds to one side only, the other side remaining flat or nearly so. Where the dip is very small on one side and very large on the other it may be called a flexure; but in fact a flexure, along its strike, may become an anticlinal. The term was first used by Mr. Hopkins; Mr. Darwin had previously spoken of such folds as "Uniclinal Curves."

† Hopkins, *Ibid.*, p. 16. This has also been noted by Mr. Martin.

now the coast section, we find a south-westerly dip at the Wish Tower, which soon carries the Upper Greensand below the shingle. There are slight rolls of the beds and changes of dips, but as a whole in going along the cliff towards Holywell we get to higher beds. Beyond this point there is a rise of the beds, and they continue rising until the Upper Greensand once more appears at the base of the cliff; and, then again rolling over, run out to sea in Beachy Head Ledge. There are, therefore, two anticlinals here; one between Beachy Head and Holywell, and one other where the new town of Eastbourn is built. Between these two lines there is, of course, one synclinal, and another between Eastbourn and the final rise of the Chalk towards Willingdon.

At Seaford there is an outlier of Lower Tertiary Beds, preserved by a very well marked synclinal; and it is, perhaps, owing to this line that the outlier at Newhaven is preserved. I cannot certainly say which synclinal line is prolonged from the east to join that at Seaford; probably it is that which is seen in the cliff at Holywell.

The mass of Tertiary strata east and west of Chichester is brought in by a synclinal fold. Highdown Hill is a mass of Chalk brought up by an anticlinal. It is quite possible that the synclinal is a continuation of that of Beachy Head and Seaford, which would enter the land in the low country near Brighton. The anticlinal of Highdown Hill may be only a local roll, or it may be the westerly continuation of that at Beachy Head. On the south of Chichester there is an anticlinal line (bringing up the Chalk), which in its strike westwards forms the Portsdown Hills.

Still further south, lying six or eight miles south of Selsey Bill, there is probably the eastern prolongation of the great flexure which traverses the Isle of Purbeck and the Isle of Wight.

Hogs Back Line.—Of the disturbances affecting the northern Lower Greensand and Chalk ranges, one of the most important is that of the Hogs Back. The arrangement of the beds is shown in Fig. 44.* The crest of this flexure apparently begins near Bentley and goes along the valley of the Wey, past Farnham, to Compton, at the western end of the Weald Clay inlier at Pease Marsh. On the northern side of this line the dip is very high, sometimes exceeding 40°. On the south side the dip is less, and the beds are sometimes flat or only slightly rolled over.† On the east of Pease Marsh the line is prolonged past Albury Park where it is distinctly anticlinal, towards Wotton (see Fig. 45.) Its eastern end is crossed by Sheet 75 of the Geological Survey Horizontal Sections, from which Fig. 46 is reduced. Here the disturbance appears to be a flexure only, and beyond this point the line cannot be traced.

There are some faults apparently connected with this line of elevation which, from their affecting the Chalk escarpment, de-

* By Mr. W. Whitaker, from "The Geology of the London Basin, Part I.," (*Mem. Geol. Survey*, vol. iv. p. 376, fig. 89). This woodcut, omitted here by mistake, is inserted at page 437.

† In the text I have spoken of this as only one line of disturbance, which in fact it is; but in the map I have marked separately the anticlinal axis, and the line just north of it, where the increased dip occurs.

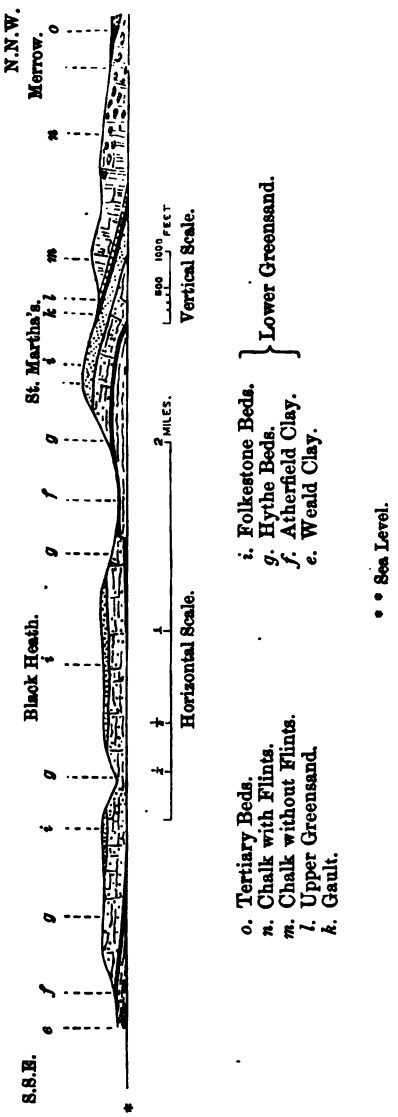
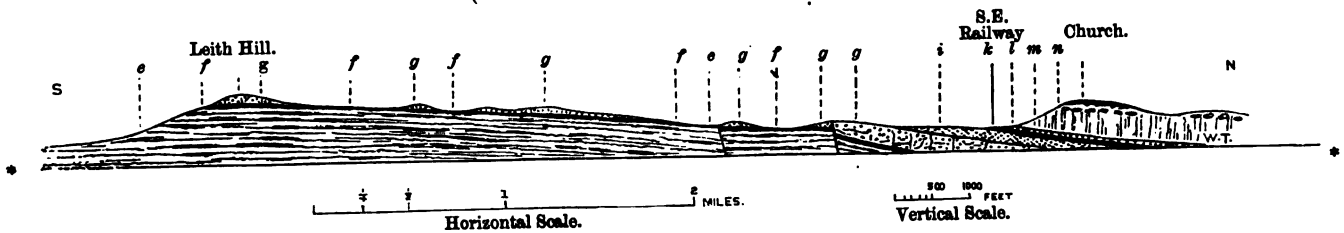


Fig. 45. Section through Black Heath and St. Martha's.

serve particular mention here. The most important of these is that about a mile east of Farnham, the downthrow of which (to the north-east) was estimated by MR. DREW at from 150 to 200 feet. The escarpment is here broken, and through the depression thus caused the railway from Farnham to Guildford runs. The other faults are on the east and west of the Wey at Guildford, and though they throw the beds at the foot of the escarpment, they have no important effect on the shape of the country.

To the west of the Hogs Back there is a line of flexure which traverses the northern part of the Hampshire Chalk area, from the vale of Pewsey eastwards through the Shalbourn and Kingsclere valleys.

Fig. 46. Section from Leith Hill to Ranmer Common.
(From Sheet 75, Hor. Sect., Geol. Survey.)



n. Chalk with Flints.
m. Chalk without Flints.
l. Upper Greensand.
k. Gault.

i. Folkestone Beds.
g. Hythe Beds.
f. Atherfield Clay.
} Lower Greensand.
e. Weald Clay.

* * Sea Level.

To the south of the Hogs Back there are two other lines, one passing east and west through Thursley and the other parallel with it, through the summit of Hindhead. The former is a flexure giving the beds a slight roll over to the north. Although the dip is sometimes high along this line, 30° and 40° occasionally, yet it is only of local importance, and has little or no influence on the features of the country. It dies out to the west of Thursley, but can be traced eastwards past Witley. Nearly in the line with this flexure there is a small fault affecting the outcrop of the Atherfield Clay; it throws down to the north.

The anticlinal which passes through Hindhead is continued to the east into the Weald Clay. The beds along the Lower Greensand escarpment west of Hambleton have in places a rather sharp dip north;—this is on the northern side of the anticlinal.

From the crest of Hindhead the beds dip south towards Haslemere.

The summit of Leith Hill coincides with a slight anticlinal. The effect of the southerly dip is plainly seen in the slipped face of the escarpment. This anticlinal, or a line of disturbance, appears to be continued a mile or two into the Weald Clay to the east; the beds in the railway-cutting south-west of Bredsell Farm having a high dip to the north.

The following notes are from Mr. Drew's MS.:—

"At Haslemere there is a strange disturbance in the valley through which the railway runs; it was well shown in the deep cutting, where the Atherfield Clay comes up with a very sharp bend, at an angle of 50° or more. The Weald Clay crops out to the east; whilst, just beyond, the sands (of the Hythe Beds) come on again; so that there must also be a fault with a throw of not less than 60 feet (the thickness of the Atherfield Clay) which dies out a few hundred yards south-west of Haslemere church. On the east another fault runs in a southerly direction from Gray's Wood, where it is an upthrow on the east, the Weald Clay occurring close to some sandstone (Hythe Beds); but at the other end on the contrary the downthrow is to the east, the evidence being the break in the line of springs which marks the bottom of the sand.

"South of St. Martha's there is a fault, first pointed out to me by Mr. Godwin-Austen, which runs from Great Tangley to Locknor Farm, and is proved by the ferruginous sands of Black Heath (Folkestone Beds) coming so near to the Atherfield Clay on the north that there is not room between for the outcrop of the whole of the Hythe Beds without a sharp dip. The throw is most likely 100 feet or more in parts; but the fault seems to die away rather suddenly beyond the two places named above. At Albury there is again a fault, the throw of which seems to be about 50 feet. The Chalk and the Gault may be seen close to one another in the road.

"In the gap through the Lower Greensand escarpment in the Leith Hill district at Pitling Street,* the Wealden shales may be

* Pitland Street on the Map.

seen in the brickyard standing vertically close to the sand, in a manner suggestive of a fault running about north and south; but this cannot be well traced out.

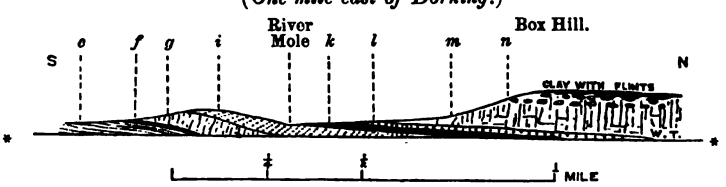
"The small fault at Upper Laylands, a mile to the east, is inferred from the springs being only on one side of the valley. The wider valley, further east, running northward from Cold Harbour is cut down to the Weald Clay in two places; both of these inliers are cut off on the north by a fault, bringing sandstone beds close to Wealden shale, the latter of which is in one case disturbed, as may be seen along the brook.

"At Cold Harbour I do not think that there is any disturbance, though there are wide cracks in the sandstone which is quarried on the hill-side; for these look as if they were caused by the the slipping of the stone over the clay which crops out just below.

"North of Leith Hill there is a long east and west fault, the greatest downthrow of which is about 100 feet (north).* The bottom of the Gault may be seen in the railway-cutting between Gomshall and Wotton, and if the boundary-line be continued eastward it would abut against the Malm Rock in the next cutting, proving that the beds are displaced. There is further evidence of this in the road west of the Rookery, where there is sandstone at a higher level than the Bargate Beds, which latter are geologically higher. There is not, however, good evidence of the fault running on by Berry Hill; but the occurrence of one near Holloway Farm, just east, is proved by the Wealden shales being brought against sand. Just beyond this fault the strike of the beds changes slightly, as shown by the curving outcrop of the Upper Greensand from Wotton to Dorking, and the dip is less."

Just on the south-east of Dorking there is a well marked flexure exposed in the railway cutting. It narrows the outcrop of the Hythe Beds considerably.† This is shown in Fig. 47; it may be a local flexure, or a prolongation of that shown in Fig. 46.

Fig. 47. Section from near Park Farm to Box Hill.
(One mile east of Dorking.)



Scale (Horizontal and Vertical).

(The references are the same as in Fig. 46, p. 231.)

"The fault east of Betchworth must have a throw of 100 feet at one point. This is proved by the occurrence of the sand of the Hythe Beds close by the 26th mile-post on the railway, which

* This is the fault which is shown in Fig. 46, page 231.

† This is not sufficiently shown on the map (Sheet 8). The outcrop of the Atherfield Clay should make a curve from Chart Park to Park Farm, and from thence, with a bend to the north, to Brockham Green.

brings the lower boundary of the Gault in a line with the Upper Greensand through which the cutting passes on the east; there is, moreover, a very plain southerly shift of the feature made by the last formation. The fault, which may be seen in the chalk-pits above, is most likely a continuation of this. Eastwards the beds dip at a less angle than on the west, and therefore each formation has a wider outcrop.

"At Wray Common, Reigate, the strike of the Chalk, Upper Greensand, and Gault changes, the beds are nearly flat and their outcrops trend north-eastward to the Merstham fault, beyond which the strike returns to its normal east and west direction and the bed dips northwards at an angle of 5° or 6°. The fault is almost wholly inferred from the direction of the boundary-lines; but the disturbance of the firestone beds in the railway-cutting at Merstham is most likely owing to it.

"The crest of an east and west anticlinal, or a line of flexure, runs south of the high road along the Lower Greensand ridge of Nutfield and Bletchingley, the dip on the north being at an angle of from 5° to 7°, whilst on the south the beds are flat."

The disturbance at Tilburstow Hill is apparently quite local. At the top of the hill the beds have a high dip to the north which rapidly lessens as we go north. Possibly the disturbance may be a prolongation of the flexure last described.

Further east, on the south of Westerham, there is perhaps a slight roll over at the escarpment. The landslips here seem to be owing to such a change of dip.

From near Moor House, Westerham, eastwards, there is a sharp flexure which bends the beds down to the north, sometimes at angles of from 40° to 60°.* Sometimes there is a southerly dip on the south side of the flexure, which then becomes an anticlinal. This line runs as far east as Montreal Park.

A little to the north of the eastern end of this line there is a sharp (but local) anticlinal, which brings the Atherfield Clay up just south of Bradbourn House. About a mile to the south there is another anticlinal which passes just north of Kippington and brings up the Atherfield Clay in the railway-cutting.

Near the Medway there are some lines of disturbance. One of them runs nearly along the turnpike-road from between Addington and Offham eastwards to Wheat Sheaf, and from thence to Leybourn; this is an anticlinal line. It may be connected, by the apparently disturbed area near Preston Hall, with a long flexure which runs from Cob Tree in an east-south-easterly direction to beyond Berstead. On the north of this line of flexure the beds dip 10° or 15° N.N.E. The effect of this flexure is well seen on the map in the straight line of outcrop of the Folkestone Beds from beneath the Gault, and also in the narrow space sometimes taken up by the Folkestone Beds.

At Maidstone itself there is an anticlinal bringing up the Weald Clay. It is continued to the east through Mote Park, Caring

* Fig. 34, p. 194 is a section through the western end of this flexure.

Street (where Weald Clay again appears) and Leeds Abbey. From thence it is continued to Upper Runham, where the Atherfield Clay again appears but not in sufficient quantity to be shown on the Map.

The strike of the Chalk escarpment changes at the Medway. On the west of that river the strike is W.S.W. and E.N.E., and the disturbance between Addington and Offham runs nearly east and west. On the east of the Medway the strike is W.N.W. and E.S.E., and here the lines of disturbance run in the same direction.

Very frequently around Maidstone very high dips are seen in sections of ragstone, and hence it has been assumed that this district is excessively disturbed; but this is an error. The apparently high dips are owing to the dissolving away of the rag, and to the fall of the beds into hollows thus formed. This is well seen in the various quarries where brickearth pipes occur. The ragstone separating these pipes is inclined in various directions and at different angles. Isolated observations, where no great amount of rock is exposed, might lead us to infer high dips in such places. When we pass from the ragstone to the Folkestone Beds, we rarely find many signs of disturbance.

The wide area of Lower Greensand around Maidstone is due partly to the anticlinal which rolls the beds over to the south, and also to the flatness of the beds over a large space south of this. All over Great Comp and Mereworth Woods the beds are nearly horizontal or have only an exceedingly small rise westwards. On the south of Kings Wood, from Chart Sutton eastwards to Ulcomb, there is a slight dip south, towards the escarpment.

Throughout the remainder of the Lower Greensand area there are no important lines of elevation. The strike of the beds continues to the E.S.E. until we come within 5 or 6 miles of the coast, when it changes to nearly east and west. The dip is pretty regular throughout the area.

The outliers of Hythe Beds on the south of Ashford appear to have been preserved along the line of a small synclinal. It is probable that the Lower Greensand escarpment once ranged along here.

There is a fault affecting the Chalk escarpment on the west side of Beachborough Summerhouse, which would pass on the east side of Tolsford Hill. The projection of the Summerhouse hill beyond the escarpment is due to this fault, which has a downthrow on the east side. A little further east there is another fault joining the last on the south. This has a downthrow to the west, and the effect of the two faults is to throw out a tongue of Gault to the south. There is no proof that this latter fault affects the Chalk. A little south-east of this there is (just in Sheet 4) a disturbance in the valley at Horne Street; but this is quite local. The beds generally are lying very nearly horizontally, there being only a very small dip to the north and east. Higher dips are seen sometimes near the cliffs, but these may be due to slips, and cannot be depended on for giving the true inclination of the beds.

It has been remarked by PROF. J. PHILLIPS * that in the great lines of disturbance which traverse the south-east of England the dip is greater on the north side than on the south side. This is very strikingly the case in many of the anticlinals and flexures which we have been considering. The Hogs Back is a familiar example. This is the case, too, with the line of flexure running through the Hindhead district, by Thursley; and also in that which runs through the Lower Greensand near Westerham (fig. 34, p. 194). In the Boulonnais there are two good examples: one is the sharp flexure seen on the coast at La Crèche, the other is seen in the railway cutting north of Caffiers † where the Chalk dips at a high angle to the north, and makes a ridge of high ground very like the Hogs Back, but of less height.

Beyond the Wealden area there are other examples. That of the valley of Kingsclere is a good one, whilst the finest is that of the Isles of Wight and Purbeck.

In all these cases the *general* dip of the whole country is to the north, and the flexure may be considered as a *local increase* of that dip. It becomes then a question of interest to inquire whether in areas in which the general dip is to the south, there are similar local increased dips forming flexures. There are a few such cases; but none of such importance as those already mentioned. In the Weald there is the flexure at Pulborough (p. 228); beyond the Wealden area there is the flexure at Windsor.‡

It is not then a universal rule that flexures in the south-east of England bend to the north, but the very great preponderance, both in number and importance, of those that do so is worthy of note.

The rule, as far as regards the south-east of England, is this: —On the northern side of great anticlinal areas there are often flexures, bending north; on the southern side such flexures rarely occur. And, further:—in subordinate anticlinals the greater dip is apt to be on the northern side. I am not aware that any sufficient explanation has been offered of these facts.§

A few further remarks upon some of the faults may be added here. A single glance at the one-inch map will show the very great tendency there is for the faults to run in a *general* east and west direction. But more than this; as the general line of Wealden elevation curves to the east-south-east, and the minor folds take the same direction, so do the faults. This is the general rule, to which, however, there are many exceptions.

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* *Manual of Geology*, p. 445, 1855.

† See a section through this flexure in *Quart. Journ. Geol. Soc.*, vol. xxiv. p. 474.

‡ See the section by MR. WHITAKER in *Mem. Geol. Survey*, vol. iv. part i., p. 191, also Hor. Sect., Sheet 74.

§ PROF. PHILLIPS remarks "because of the unequal declination of the strata on the opposite sides of the ridges, we may perhaps admit the [disturbing] force to have been exerted in an *oblique* direction. This latter conclusion has often been suggested to us while considering the ordinary phenomena of faults."

The large preponderance of east and west faults over those running north and south will be evident from the following measurements which I have made of lines of fault in Sheet 5:—

Faults running approximately east and west 260 miles.
" " " north and south 30 "

As regards the direction of the throw of these east and west faults, there is, along the northern side of the Hastings Beds area, a very marked tendency to throw down to the south, the effect of which is to repeat the beds as they rise toward the central district, and to cover a large tract of country with beds high up in the series. Most of the long and the more important faults throw down to the south. This is the opposite direction to that in which the flexures *bend:* flexures generally bend to the north; faults generally throw to the south.

On the south of the central area there is less regularity in the throw; but even here there seems to be a tendency in favour of a downthrow to the south.

The *slip* of the fault has not always taken place in a vertical direction, but sometimes in a direction more nearly approaching the horizontal; that is to say, the beds have had a *lateral* as well as a vertical slip. Two excellent examples of this have been given in the descriptive part of this Memoir; one east of Hastings (p. 62), and one near Horsham (p. 90). In each case the throw is down to the north, and the lateral slip is to the west. These two faults "hade" considerably; the former at an angle of 50° from the vertical, the latter at 60°.

Some excellent examples of "trough-faults" are given in figs. 5 and 12 (pp. 59 and 83). Such faults as these are at first difficult to understand. A good deal has been written upon this subject by MR. HOPKINS,* PROF. PHILLIPS,† and MR. JUKES.‡ Their explanation is that trough-faults originated during upheaval, when the area containing such faults became for a time an anticlinal with fractures, and that down these fractures the trough-shaped masses slipped;§ when the area settled down again into an approximately horizontal position the gaps closed up with great lateral pressure. The evidence of this pressure MR. JUKES found in the South Staffordshire coalfield, where the coal on each side of the trough-fault was reduced to dust by pressure.

Such a theory *may* be necessary in some cases, but a much simpler explanation will suffice for the faults shown on p. 59. This will best appear from an examination of fig. 48, in examining which we will suppose ourselves to be looking north. In A there is an ordinary fault (*a*, *b*) throwing down to the west. In B the beds and fault are traversed by a second fracture (*c*, *d*), along which a second slip takes place, and the result is a trough-fault C.

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* *Phil. Trans.*, 1842, p. 52.

† "The Malvern Hills," *Mem. Geol. Survey*, vol. ii. part i. p. 142.

‡ "South Staffordshire Coalfield," 2d ed., *Mem. Geol. Survey*, p. 194. *Manual of Geology*, 3d ed., p. 214.

§ See MR. SCROPE'S *Volcanoes*, p. 49 of 1872 ed.

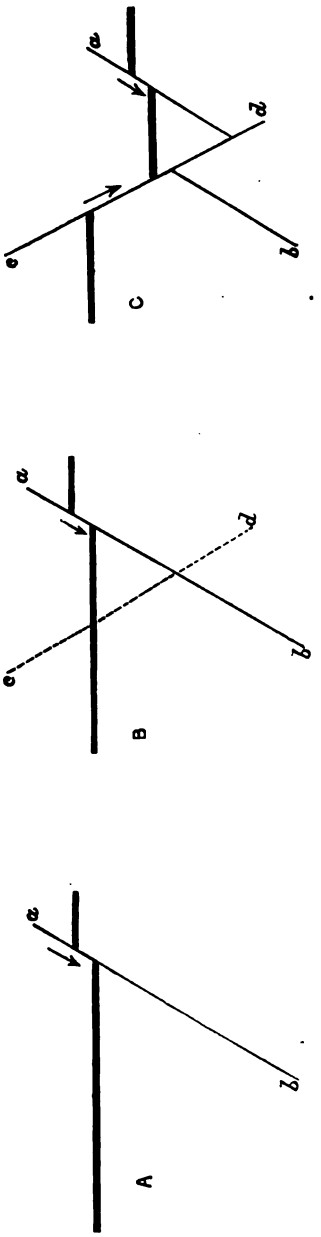

Fig. 48. Diagram to illustrate the formation of a Trough-fault.

This explanation perfectly suits the case figured on p. 59. Here the lower and faulted end of the first fault was plainly seen as a closed crack on the quarry face. It is evident that such an interrupted fault as *a*, *b*, is absolutely necessary to explain the trough; and I think it very likely that in the case shown in fig. 12, p. 83, I may have overlooked the continuation of the second

line; the displacement here is very small. It may be too that in some of the trough-faults of the coal fields described by MR. JUKES the continuation of the earlier fault has been overlooked. In his enlarged drawing of the trough there are some minor faults which are clearly faulted in the manner just described.*

If we draw a line from Leith Hill (967 feet) to Fairlight Down (583 feet) we shall find it passing very close to the intermediate summits, but keeping a little to the south of them. This line is almost exactly 50 miles in length, yet the distance of the summits to the north of this line are only as follows:—Brightling Down (636 feet), half a mile; Crowborough Beacon (803 feet), two miles; Turner's Hill, one mile. If we turn to the map of anticlinal lines we find that these five points are on *different* lines of elevation, unless Turner's Hill be on the same as Crowborough, as is possibly the case.

Again, if we draw a line from Fairlight Down to the highest point of the North Downs (872 feet), which is a third of a mile east of Flint House, and $1\frac{1}{8}$ mile N.E. of Limpsfield, it will pass exactly through Frant, which is the highest point of the north-eastern Hastings Beds area; it will touch the Wadhurst ridge, also a high point; and it will pass two miles to the S.W. of the summit of the Lower Greensand in Kent and E. Surrey (810 feet). This is to the south of Brastead Chart, and half a mile N.W. of Toy's Hill.

Probably these are only accidental coincidences for which no special explanation need be sought. They do not seem owing to any cause connected with the upheaval of the district, for, as already stated, the summits mentioned are either the culminating points of different lines of elevation, or they are wholly due to the denudation of the surrounding country.

There is one other fact which is worth noting here. The greatest "geological elevation" of the Lower Greensand is not opposite to that of the Chalk; the former is at Leith Hill,† the latter near Flint House. A line through these places points towards (but to the east of) Gravesend, near which place the Chalk rises somewhat, separating the Tertiaries of London from those of Sheppey. This seems to indicate an *oblique anticlinal*, branching off from the general east and west anticlinal of the Weald. The dip of the beds resulting from this oblique anticlinal is so exceedingly small that they cannot be observed in sections, and the line can only be determined by viewing the country on a large scale.

There are some further coincidences connected with the summit levels for which a sufficient explanation can be given; they being

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* Since writing the above I have found that MR. PRESTWICH has figured some trough-faults in his memoir on "The Geology of Coalbrook Dale" (*Trans. Geol. Soc.*, ser. 2, vol. v. p. 454). These disturbances, he says, are difficult to account for and for most of them he gives the same explanation as does MR. JUKES. He, however, gives a sketch of the *intersection of two faults*, resulting in a trough, which is the same as that described above.

† Perhaps, however, the great height of the base of the Lower Greensand at Leith Hill, may be due (wholly or partly) to the great thickness of the Weald Clay there. (See note on p. 96, and compare the remarks on pp. 241, 242.)

due to the old plain of marine denudation, of which we shall have to speak in a succeeding chapter. Perhaps these very interesting and important facts can best be shown by tabulating the heights in various ways. First we will take the highest summits of each formation in descending order. Inkpen Beacon is not in the Weald but forms the meeting-point of Hants, Wilts, and Berks; it is the summit of the Chalk range in England.

I. Table of culminating points of each formation.*

	Feet.	
Inkpen Beacon - -	- 972.	Summit of the English Chalk.
Leith Hill - - -	- 967.	Summit of the Lower Greensand in W. Surrey and Hants.
Hindhead - - -	- 894.	
Butser Hill - - -	- 882.	Summit of the Chalk in W. Surrey and Hants.
Point N.W. of Limpsfield	- 876.	Summit of the Chalk in E. Surrey and Kent.
Ditchling Beacon -	- 814.	Summit of the Chalk in E. Sussex.
Point S. of Brastead -	- 810.	Summit of the Lower Greensand in E. Surrey and Kent.
Crowborough Beacon -	- 803.	Summit of the Hastings Beds.

II. Table of culminating points of each formation,† from west to east. Showing the *general* fall of the summits in that direction.

		Feet.	
	Inkpen Beacon - - - -	972	
Northern Chalk Escarpment (North Downs).	White Down, N. of Wotton - -	744	
	N. of Reigate - - - -	767	
	N.E. of Bletchingley - - -	775	
	N.W. of Limpsfield - - -	876	(summit)
	N. of Westerham - - -	812	
	Knockholt, W. of the Beeches - -	783	
	N.W. of Wrotham, S.W. of Horse and Groom - - - - -	774	
	E. of Deptling - - - -	657	
	Hollingbourn Hill - - -	606 × †	
	Charing - - - - -	? 640†	
	Paddlesworth - - - -	626	
	Tolsford Hill - - - -	562 ×	
	Folkestone Hill - - - -	575 ×	

* In these tables, as elsewhere in this volume, the heights are reckoned from *mean sea level* at Liverpool. × signifies that the figures are from the old Ordnance Survey, and may perhaps require some small correction; † that the heights given are possibly not quite the highest for the district in question, although the true summits would not greatly exceed those figures; ? signifies rough estimates. All numbers not marked by these signs are taken from recent Ordnance Surveys or the War Office Survey, and may be considered as absolutely correct. The differences between the results of the old and new survey is very great in Ditchling Beacon; the former gives 858 feet (from low-water mark), the latter 814 feet from mean sea level. The heights in the Boulonnais are from the French Government Map; I do not know the datum line.

† I regret having no heights to give of the Lower Greensand in Sussex. Probably a series of heights along this formation would show a more regular fall from west to east than either of those here given.

Northern Lower Greensand Escarpment. (Quarry Hills in East Kent.)	Hindhead	894	
	Holmbury Hill	857	
	Leith Hill	967	(summit)
	Tilburstow Hill	591	
	S. of Brastead	810	
	S. of Sevenoaks	707	
	Great Comp Woods, (highest point of)	551	
	S.E. of Maidstone	? 450	
	N. of Lympne	? 350	
Hastings Beds (Forest Ridge.)	Crowborough Beacon	803	(summit)
	Brightling Down	636 ×	
	Fairlight Down	583	
Southern Chalk Escarpment (South Downs).	Butser Hill	882	(summit
	Chanctonbury Ring	804 ×	
	Ditchling Beacon	814	
	Firle Beacon	810 ×	
	Beachy Head	532	

III. Heights *across* the Wealden area, from south to north.

		Feet.
a.	Butser Hill (Chalk)	882
	Hindhead (L.G.S.)	894
b.	Chanctonbury Ring (Chalk)	804
	Leith Hill (L.G.S.)	967
	White Down (Chalk)	744
c.	Firle Beacon (Chalk)	810 ×
	Crowborough Beacon (Hastings Beds)	803
	S. of Brastead (L.G.S.)	810
	N. of Westerham (Chalk)	812
	(Chalk summit, 3 miles west of last point, 876)	
d.	Beachy Head (Chalk)	532
	Fairlight Down (Hastings Beds)	583
	Folkestone Hill (Chalk)	575
e.	Mont Violette, E. of Neufchatel (Chalk)	594
	Mont Lambert, E. of Boulogne (Weald outlier)	617
	Mont Couple, E. of Wissant (Chalk)	534
f.	S. of Long-Fosse (Chalk)	695
	Signal de Colembert (Chalk)	666

b, *c* and *e* are along lines drawn nearly at right angles to the strike of the beds. *d* is a line along the English coast, which is slightly oblique to the dip. *e* is a line a few miles from the French coast. *a* and *f* are lines oblique to the dip, *a* is through the greatest heights at the western end of the Weald. *f* is through the greatest heights (or nearly so) at the eastern end of the Lower Boulonnais

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In the foregoing pages, and elsewhere in this volume, I have spoken of the "upheaval of the Weald" as an acknowledged fact, about which there is no dispute. All geologists have regarded the Wealden area as one of simple upheaval, and some theories of Wealden denudation are wholly based upon the assumption that such an upheaval has taken place.

At the time that these pages were sent to press I too fully accepted this theory. Subsequent investigations, however, have

led me in some measure to doubt its truth, and I now think that some of the "dip" (and apparent upheaval) of the Weald may be due to original inequalities of deposition. I endeavoured to show this at the Bradford meeting of the British Association (1873), in a paper "On the Correspondence between some areas of apparent Upheaval and the Thickening of Subjacent Beds."* Illustrations were drawn from the Weald, the Oolitic rocks of the Central Counties, the Yoredale Rocks and Millstone Grit of Derbyshire and Yorkshire, and the Lower Cretaceous Rocks on the west of the Paris Basin.

In all these cases it was shown that the rise of the beds is in proportion to the known thickening of other beds which underlie them. Hence we may infer that the rise of the beds in such areas is not wholly due to the upheaval,† but that it is due, sometimes partly, sometimes *wholly*, to the *sum of the thickening of the underlying beds.*

Plate VI. shows this as regards the Weald. The exact thickness of the Oolitic rocks is of course doubtful, and we are uncertain as to the exact points to which the various rocks extend; but there is no doubt that they do thin out against the Palæozoic floor in the way here shown.

I have drawn the floor of Palæozoic rocks as a straight line, taking the depth at which it was found at Kentish Town; but this is done for simplicity, and because there is as yet no evidence as to its depth and range. Such evidence we hope the Sub-Wealden Boring will soon yield us.

If it be granted that the thickening and thinning of lower beds thus affects the rise and dip of higher beds, we must in all cases be careful how we infer great movements of the earth's crust from the observed rise and dip of beds. This is of the more moment when important theories have been built upon such supposed movements, as is the case with the Weald.

In the diagram here given I have only shown the northern side of the Weald. We have no knowledge whatever of the position of the Palæozoic rocks under the southern part; nor have we, as yet, any means of knowing if the beds thin out in that direction as they do to the north. Possibly they do not, and the "dip" may be really due to movements of the strata; we can hardly refer the sharp flexures of the Weald to any cause but this, and the faults, of course, are infallible proof of disturbance.

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* Since published in *Quart. Journ. Geol. Soc.* vol. xxx., p. 186. To this paper I may perhaps refer the reader for a fuller discussion of the question.

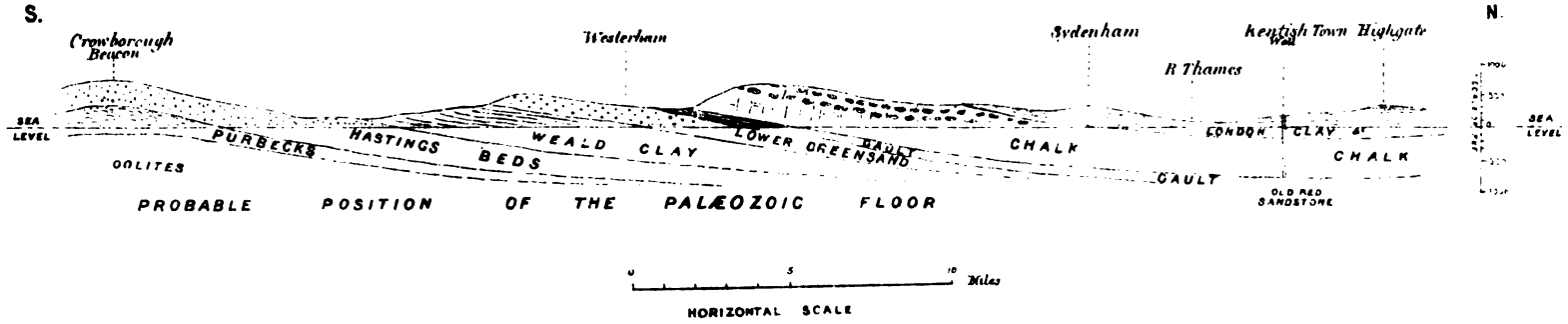
† I speak only of the *relative* upheaval, comparing (say) the "geological elevation" of the Chalk which once spread over the centre of the Weald with that which it has in districts to the north and south. That the whole district has been repeatedly raised above and depressed below the sea is of course undisputed.

to face page 142.

PLATE VI.

SECTION THROUGH PARTS OF THE WEALD AND THE LONDON BASIN,

SHOWING THE CORRESPONDENCE BETWEEN THE APPARENT UPHEAVAL OF THE WEALD AND THE THICKENING OF SUBJACENT BEDS.



Drawn by W Topley

CHAPTER XV.—SCENERY AND AGRICULTURAL CHARACTERS.*

Hastings Beds.—Once more we return to the higher districts of the Hastings Beds, the internal structure of which, together with some account of their external features, have been noted in the last chapter.

Standing then upon a prominent point of the Fairlight ridge, which has been already mentioned as coinciding very nearly with the central anticlinal line, we see to the east and west a line of high land, apparently tolerably level, but in reality falling slightly to the west. Around Fairlight Mill and Church, and, as a rule, wherever the Ashdown Sand form the subsoil, the country is open and, in some places, waste. The soil is light, and, for the most part, poor.

From Fairlight Mill a magnificent view of the country can be obtained. On the south we see the Chalk escarpment, stretching from the bold promontory of Beachy Head for many miles to the west. Between the ridge on which we stand and the Chalk there is no high land; but the ground falls, somewhat steeply at first, more gradually afterwards, to the undulating plain on which Bexhill, Ninfield, and the neighbouring villages stand. This plain is really a table-land, cut through by valleys which divide the Tunbridge Wells Sand into a great number of outliers. Beyond this there is the great alluvial flat of Pevensey Level. The Lower Greensand, along its south-western range, makes only a very small feature on the ground.

On the north-east the view extends across the broad flat of Romney Marsh, to the Chalk beyond Folkestone, and from thence along the escarpment for some miles to the west; the comparatively low ground of the Lower Greensand near Ashford allowing the Chalk behind it to be well seen. Still further to the west the view is shut out by the high land of Frant; and nearer, but more to the south, by the Brightling ridge.

Far away to the east we can just make out the dark cliffs of Boulogne, which sink gradually beneath the sand-dunes on the south, and so become lost to view. But further north, where the Chalk cliffs come on, we see a broad line of light, just fringing the horizon.†

Leaving now the highest summit, we take the road to Battle, which runs nearly along the crest of the anticlinal line; and in doing so we follow very closely, but are probably a little north of, the line of march of the Norman army on the day before the

* "The Agricultural Geology of the Weald" has been described in the *Journ. Roy. Agric. Soc.*, ser. 2, vol. viii., p. 241, 1872; this paper contains a Geological Map, in which the various soils are represented by shading.

† To make out this distant coast a clear sky is needed. A little before sunset is the best time, the Chalk cliffs being then fully lit up. It is stated in *Murray's Guide* that the French coast is occasionally visible from Brightling. According to LOWER (*Hist. of Sussex*, vol. 1, p. 171), the view from Fairlight Down embraces 10 towns, 66 churches, 5 castles, 40 windmills, and 70 martello towers.

great battle. Telham Hill, the western end of the Fairlight ridge, was the Norman resting ground that night; whilst the English army was drawn up on the rising ground to the north-west. Both positions were nearly on the watershed; that of HAROLD being excellently chosen for defending the "pass" which lay between the opposing armies.*

There are other "passes" at Darvel Hole, 1½ mile to the south-east of Brightling, and a little west of Dallington; beyond this the ground opens to the wide expanse of high sandy land around Heathfield and Cross-in-hand. There is a good deal of wood-land over this district, more, in proportion to its size, than there is over the other and greater area of Ashdown Sand, that of Ashdown Forest; but there the lower ground is much wooded.

These two great areas of Ashdown Sand are thinly populated. St. Leonard's Forest is still less inhabited; whilst the great area of sandy land overlying the Tunbridge Wells Sand in the north-eastern district is fairly peopled.

Looking north from the high ground of Heathfield and Cross-in-hand, we have before us a broad valley which is mainly a synclinal, as already described (p. 221); bounding this on the north-east is the Wadhurst and Ticehurst ridge, and to the north-west the still higher ground of Ashdown Forest. On the north there are the outliers of Tunbridge Wells Sand near Rotherfield (Argus Hill, Castle Hill, &c.). Thus from Ticehurst to Rotherfield, and again from Crowborough westwards, the view is bounded exactly by the watershed of the Medway. It is only between Castle Hill and Crowborough that the watershed sinks low enough to allow a little of the country on the north of it to be seen. The view to the north is thus much less extensive than that from Fairlight Down; to the south, the views from both places are very much alike.

The high ground of Ashdown Forest is bare and bleak, and the soil is everywhere poor. There are several small fir plantations on prominent points, which are visible for many miles in every direction. The views of the South Downs from those points are exceedingly fine, particularly at sunset. The coach-road from Tunbridge Wells to Uckfield passes over the summit and affords extensive views over the Weald at every turn. The railway between the two places, taking lower ground, gives a more detailed idea of the country. The line of railway which gives the most characteristic views of Wealden scenery is that from Tunbridge Wells to Hastings.

The smaller streams which are deeply cut into the sandy beds often give some picturesque pieces of scenery. This is especially the case with those which cut down through the Wadhurst Clay to the Ashdown Sand. Where the dip is small the junction is

* I use the term "pass" in its proper signification, that of a considerable though not very wide depression in the line of watershed. The term "watershed" I use in its ordinary signification, that of a line *along* which, or *from* which, water is shed. See upon this point SIR J. HERSCHEL, Physical Geography, p. 120 of 1st ed.; he gives to this line the term "water-sched," and by "water-shed" he means the slope *down* which the waters run.

usually marked by a rapid descent when the sand bed is reached; sometimes producing a waterfall, such as are well known in the neighbourhood of Hastings, at "Old Roar," Fairlight Glen, and elsewhere. When the beds dip down the valley such falls do not often occur. The streams which run from the Ticehurst ridge to the Rother have their beds formed for long distances by the top bed of the Ashdown Sand.

These steep-sided wooded valleys are called "Gills," a word which, in the south-east of England, appears to be confined to the Hastings Beds country.* It is not used, I think, on the Lower Greensand; whilst on the Weald Clay "Gills" scarcely exist. The term is in common use in the north of England.

SIR JOHN HERSCHEL, who lived at Collingwood, near Hawkhurst, has given the following description of the valleys there †:—

"In the Weald of Kent, a district abounding in grassy slopes and winding and branching valleys, in the calm clear nights which are there so frequent, beautiful instances of radiation-fog are of perpetual occurrence. Immediately after sunset, in clear weather, dew commences—streams of cold air set downwards, following the lines of shortest descent (very sensible as descending currents), their course being marked with mist, thin and filmy at first, but acquiring density in its downward progress, and by degrees filling the valleys with fog, which, in the morning before sunrise, presents exactly the aspect of a winding lake or river of water, whose surface, perfectly even and horizontal, runs a sharply defined level line round every promontory and into every retreating nook. Descending into such a lake under a full moon, a few yards below its upper surface, a *lunar rainbow is frequently seen* in the mist. We, on more than one occasion, have resorted to a particular spot well situated for the purpose, to look for one, and have not been disappointed."

The sandstones in the Hastings Beds country often stand out as natural rocks, either just projecting through the earth or rising in continuous walls. These rocks occur beneath clay beds. They have been mentioned in the foregoing detailed description of the country, but their picturesque effect in many landscapes entitles them to a separate mention here.

The best known and finest examples of such natural rocks are those around Tunbridge Wells. Frequently the sand composing them is coarse grained at the top, but lower down the grains are finer and the whole mass very homogeneous in structure. To this, and to their few joints or other plains of division, the preservation of the rocks is probably owing. It is not to their superior hardness; for, when freshly cut, the sand is often exceedingly soft and crumbling, but hardens on exposure. The weather also gives to the rocks their dark colour, for the freshly-fractured face is generally light-coloured, and often almost white.

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* "Shaw" is another word in common use in the Weald. This denotes a narrow strip of wood, either on the flat or occupying a small and shallow valley. It is common enough to find fields divided by shaws in place of hedge-rows.

† *Meteorology*, p. 92, 1861.

*Natural Rocks; top bed of the (Upper) Tunbridge Wells Sand.**
Fig. 49. Harrison's Rocks, near Tunbridge Wells.

Fig. 50. The Toad Rock, Rusthall Common.

* These woodcuts are from photographs. The conical building in fig. 49 is an "oast-house," a place for drying hops.

*Natural Rocks; top bed of the Lower Tunbridge Wells Sand.**
Fig. 51. *Great-upon-little, West Hoathly.*

Fig. 52. *Rocks, near Rocks Farm, Buxted.*

* These woodcuts are from drawings by GRIMM in the BURRELL MSS., British Museum.

Sometimes the rocks stand out in isolated masses and assume irregular forms, as in the well-known "Toad Rock," on Rusthall Common, Tunbridge Wells (Fig. 50).

At West Hoathly there are some fine examples of natural rocks. These belong to a lower horizon than those around Tunbridge Wells, and immediately underlie the Grinstead Clay. One of the most curious, known as "Great-upon-little," is shown in Fig. 51.*

Natural rocks on the same horizon occur frequently to the west and north of Uckfield. A very good example is shown in Fig. 52; this represents a line of rocks running parallel with and slightly to the north of an east and west fault, which is seen in section in the road close by. "The Rocks," on the west of Uckfield are probably well known to readers of DR. MANTELL'S writings, the same account having done duty in several works.†

The Lower Tunbridge Wells Sand is rocky near Balcombe; its character is very well seen at the railway station, and in the country around.

The rock-bed at the top of the Ashdown Sand often projects through the soil, but does not often form lines of natural rocks. The best examples I know are those around the Ecclesbourne Valley, and on the hillside immediately east of the old town of Hastings. They are also seen in Crowhurst Park, and there are some in Rocks Wood, on the west of Mayfield, which may be on this horizon. St. Clement's Caves at Hastings are dug out of this rock-bed; the widened joints are sometimes filled up with Wadhurst Clay fallen from above; when first dug into, the rock-sand is very soft, so that the labour of excavating these caves is much less than is generally supposed. The surface hardens on exposure. These caves are believed to be *wholly* artificial, but there are some at West Hoathly, in Lower Tunbridge Wells Sand which are probably natural; here the caves seem to have been formed along joints, their walls are thickly encrusted with carbonate of lime.

Such forms as the Toad Rock and Great-upon-little are, perhaps, best accounted for by the following explanation of similar rocks in Derbyshire,‡ such as are very often cited as old "Sea Stacks":—"A very large number of these rocks are undercut, or worn away more in the lower than the upper part; this was for a long time a puzzle to us; if the rocks had been all pretty much on the same level, it might have been that the upper parts of all the weathered blocks belonged to the same hard bed, and the lower parts to one somewhat softer; but they

* This rock is described, and figured, by THOS. POWNALL in *Archæologia*, vol. vi. p. 54, 1779.

† See the description in *Fossils of the South Downs*, 1822, p. 26; reprinted in the following works:—Appendix to HORSFIELD'S *Hist. of Lewes*, 1824, p. xiv., *Geology of the South-east of England*, 1833, p. 203; HORSFIELD'S *History of Sussex*, vol. 1.

‡ *Mem. Geol. Survey*, "*The Geology of . . . . . North Derbyshire . . . . .*" by [PROF.] A. H. GREEN, DR. C. LE NEVE FOSTER, and J. R. DAKYNS, p. 40.

For some interesting observations on erosion by sand, see DR. TYNDALL'S lecture on "Niagara," *Macmillan's Magazine, May* 1873.

are found scattered up and down at very different heights, so that this explanation would not do. Professor Ramsay on his visit threw out the following hint on the matter:—The rock, wherever it is exposed to the air, weathers down into coarse sand, which lies thick over those parts of the hill-top which are bare of peat. During high winds this sand is of course blown against anything that comes in its way, and acts like a natural file or emery powder; but as the wind cannot lift the heavy grains far from the ground, it is the lower part of the obstacle that will be most worn away, and hence the rocks are hollowed out below. If anyone doubts whether the means assigned are sufficient for this end, we recommend a visit to the spot during a moderate gale, and an attempt to hold the head a few feet from the ground with the face towards the wind. It is clear that in time large masses of rock might be thus carried away altogether, by what may be called æolian denundation."

The *soil* of the Hastings Beds varies considerably. Over the larger sandy tracts it is light and generally poor, whilst over the clays it is exceedingly stiff. The Wealden Clays are remarkable for the extent to which they crack in drying, so much so that walking over a clay field in very dry weather is often a rather hazardous undertaking. In this respect, and in many others, the Weald, Wadhurst, and Grinstead Clays closely resemble each other. There is one great advantage that the clays of the Hastings Beds possess, and that is, *natural drainage*. It is exceedingly rare to find any great area without a fair fall, so that the land can be drained with facility. On the Weald Clay it is often exceedingly difficult to obtain a fall, whilst the trunk drainage is generally so badly cared for that the meadows are flooded for weeks together, and the drainage waters held back. Over the Hastings Beds there is almost everywhere a marked slope at the edge of the alluvium—steepest, of course, where sand crops out; and so the drainage waters can be discharged on to the flats. Here they may remain, for the brooks are often as badly cared for in the one district as in the other.

The Wealden sands are, as a rule, exceedingly fine in grain, and, when "puddled" or "poached" the soil holds up water almost as well as clay. From this reason we often find rushes growing thickly over a sandy district. Indeed a little caution is necessary in examining the country, and strict allowances must be made for the weather, or a stranger may make sad mistakes as regards the nature of the soil. Sometimes there is a small quantity of pipe-clay with the sand, and this still further masks its true character.

This clayey character of the sands has often an unfavourable effect upon the farming, for it is difficult to feed sheep on the land with turnips; a process essential to the management of light soils.

The cultivation of *Hops* is so essentially characteristic of the Weald that the subject must not be passed over entirely. There are four districts in the Weald in which they are chiefly grown,

which taken in order of the quality of produce, are:—Farnham, Maidstone, Hadlow, and the Hastings Beds generally, but more especially in their eastern and central parts. The railway from Tunbridge Wells to Hastings goes through the heart of the hop country. The cultivation extends a good way to the west, chiefly over the lower grounds; but comparatively few hops are met with west of Uckfield.*

The soil which suits them best is a deep clayey loam, such as occurs on the lower slopes of many valleys, and on their alluvial flats. The old alluvial brick-earth of the Medway around Hadlow makes an excellent soil for them. This remark applies to the Weald Clay and Hastings Beds, where, as a rule, the coarser varieties are grown. Over the ragstone district, near Maidstone, the hop-gardens are mostly on very stony calcareous soil; but hereabouts there are numerous veins of brick-earth (see p. 197), the loam from which may get mixed with the decomposed rag. But the opinion sometimes expressed that a calcareous soil is necessary for hops is certainly a mistake. Very few Wealden soils can fairly be called "calcareous" or even "marly"; unless they be artificially made so.

The following is an analysis of "a good siliceous sandy soil "from a hop-garden near Tunbridge, Kent,"† probably on the old alluvia of the Medway:—

Water of absorption		4·75
Loose stones and gravel, principally siliceous		13·25
Undecompounded vegetable fibres		3·50
Fine siliceous sand		53·00
Minutely divided matter separated by agitation and filtration:		
Carbonate of lime	4·75	
Carbonate of magnesia	0·75	
Matter destructible by heat, principally vegetable	3·75	
Silica	5·25	
Alumina	3·25	
Oxide of iron	1·25	
Soluble matter, principally common salt and vegetable extract	0·75	
Gypsum	0·50	
	20·25	20·25
Loss		5·25
		100·00

The foregoing is the only good analysis of a Wealden soil with which I am acquainted. There is one other, also by Sir H. Davy,

* Mr. Bristow informs me that there is a tradition at Uckfield that the first hop-garden in Sussex was planted there. Lower (*Hist. of Sussex*, vol. i. p. xiv.), says, "Hops were first introduced into England by a Sussex man, Leonard Mascall, of Plumpton, *temp.* Henry VIII." The first hop-garden in Surrey was probably at Farnham. For an excellent account of hop culture see a paper by S. Rutley, *Journ. Roy. Agric. Soc.*, vol. ix. p. 532, and the article "*Hop*" (by J. M. Paine), in *Cyclop. of Agriculture.*

† Sir H. Davy, *Agric. Chemistry*, 2nd ed p. 172, 1814.

of a soil in Sheffield Park "remarkable for producing flourishing oaks"*; these, so far as I know, are the only analyses published:—

Silica	54
Alumina	28
Carbonate of lime	3
Oxide of iron	5
Decomposing vegetable matter	4
Moisture and loss	3
	97 [?]

Sheffield Park is on Tunbridge Wells Sand; this analysis contains far too much clay to serve as an average example, nor are the sandy soils of the Weald remarkable for oaks, the clay soils certainly are.

Weald Clay.—This is the most featureless division of the district. Along the northern boundary of Romney Marsh the termination of the Weald Clay is certainly an old sea-cliff, now worn down into undulating ground The height of the country here is sufficient to allow streams, rising within three miles of the old coast line, to run northwards into the estuary of the Thames, with a course of nearly 30 miles. Further east, as far as the Medway the country is excessively flat; along and near the Beult and Teise the ground is much covered with gravel and loam, through which the streams have cut their way down to the clay. But these outliers of gravel scarcely at all affect the tameness of the scenery, the slopes of each being very gentle.

On the west of Yalding, the country is more hilly near the Lower Greensand escarpment. This is partly owing to the outliers of gravel which have been preserved at a great height above the river. The base of the Lower Greensand here attains a considerable height; from about the road between Sevenoaks to Tunbridge, as far west as Cockham Hill, its height is 500 feet. On the south of this line the bottom of the Weald Clay is from 80 to 100 feet above the sea, so that there is a fall of 400 feet in four miles, the space being itself cut into by valleys. This district is perhaps the most varied in form of any of the Weald Clay area. As we proceed westwards the surface again becomes tamer, but what features there are have a closer relation to the true geological structure of the country than have those which we have been considering. The outcrop of the Paludina Limestone makes a well-marked rise in the eastern part of Sheet 8, and so do some of the beds of sand.

Rising from the valley of the Mole the top of the Weald Clay attains a height of 700 feet at Leith Hill. It sinks considerably at the Wey, but rises again to a great elevation near Hambleton and Hindhead. The area shown on the map as occupied by gravel is comparatively tame. None of this gravel attains heights above the stream at all comparable with that of the Medway. Near the Lower Greensand escarpment, chiefly at points removed from the larger streams, there are patches of angular gravel, the remains

* SIR H. DAVY, *Agric. Chemistry*, 2nd ed., p. 175. 1814.

of, or wash from, the escarpment which once reached further south. This "gravel" has in part preserved the underlying clay from denudation.

On the southern part of the Weald Clay the country is less varied in form, but the outcrops of the sand beds often give rise to definite features. The soil of the clay is stiff, that over the sand beds is light. MR. MARTIN states that the outcrop of the sands and calcareous sandstones "may be generally detected by the occasional growth of elm trees. This agricultural test may be depended upon in all this part of the Weald, except when there are diluvial deposits." *

The natural wood of the Weald Clay is oak, hence WILLIAM SMITH'S name of "Oak-tree Clay."

Lower Greensand.—The general surface features of this formation will be evident from an inspection of the sections given in the last chapter. Its most characteristic feature is the escarpment which bounds the flat lands of the Weald Clay. The old coast line on the north of Romney Marsh has cut this escarpment, obliquely, beyond this it shows with tolerable distinctness at Aldington, but for some ten miles to the west of that place it is exceedingly indistinct. This may be owing to the faults near Ashford, which, running obliquely to the strike, have broken the continuity of the beds. It is possible, however, that the true escarpment has once existed here, or a little to the south of the present mass of the Lower Greensand, but that it has been destroyed in retreating northwards. From Aldington north-westwards to Pluckley there are several outliers of Hythe Beds, which seem to mark the line of a former escarpment. In this distance of nine or ten miles there are a larger number of outliers of Hythe Beds than are to be found in all the rest of the Wealden area; and *nowhere else is the escarpment interrupted*, save at the transverse valleys, and in the eastern part of Sheet 5, where the Lower Greensand is greatly diminished in thickness and contains no hard beds.

The Lower Greensand near the Kentish coast has but very little wood or waste land. The sandy Folkestone Beds, which elsewhere have a good deal of their area in waste lands, are here well cultivated. This is probably owing to the calcareous stone (Folkestone Stone) which they contain, and which they lose some six miles or so to the west. As the beds change in character so does the soil above them; so that from Ashford westwards, and all through Kent, Surrey, Hants, and as far through Sussex as the beds keep their distinctive characters, there is one long succession of commons and heaths.

The Sandgate Beds, containing a good deal of clay, give rise to a damp soil, far lighter than that of the Gault or Weald Clay, but stiff in comparison with that of the adjoining Lower Greensand

* *Western Sussex*, p. 47.

divisions. Springs very often break out at the junction with the Folkestone Beds.

The Hythe Beds form a light, stony, and dry soil, but of these we will have more to say immediately.

The Lower Greensand area near Ashford (and that to the east of it) has one peculiarity, besides the absence of a well-defined escarpment; that is the extent to which it is furrowed by valleys which drain inwards towards the Weald Clay. This, perhaps, is only re-stating in another form what has already been said as to the absence of a definite escarpment here. But from the look of the ground near Aldington and Lympne one may conclude that the escarpment, which once ranged over what is now the north-eastern corner of Romney Marsh, was continuous, and resembled in character that on the east of Pluckley. Yet the streams near Hythe and Folkestone run southwards and have carved the Lower Greensand table-land into steep-sided and picturesque valleys. These valleys, if prolonged to the south, would cut the old line of escarpment. It may be however that they represent only the higher branches of a longitudinal valley running along the old plateau from west to east, and which would drain into the transverse valley of the old Rother, where are now the Straits of Dover; just as the longitudinal valley of the Len now receives streams from the north, and flows into the transverse valley of the Medway.

It is not until we get to the watershed of the Stour and Medway that the Lower Greensand country as a whole presents its normal features. From a little west of Egerton to the Medway the escarpment ranges without a break. Near Chart Sutton, Ulcomb, &c., the slope is less steep than usual; this is probably owing to the slight southerly dip which the beds have there. The road from Chartway Street westwards to Cox Heath runs along high ground. From here there is a *general* fall to the north, though as a whole the Hythe Beds hereabouts form a wide plateau.

The most fertile district of the Hythe Beds is that near Maidstone. Enormous quantities of hops are here grown; and also of filberts and fruit. As already stated, the fertility of this district may in part be due to the veins of brick-earth which intersect it, but it would seem that the ragstone soil itself is more fertile here than elsewhere.

There is a great difference in the character of the country east and west of the Medway. On the east the Hythe Beds are largely in arable culture and are well peopled; on the west they are very much covered with wood and are thinly populated. This is especially the case with the higher districts, and it may be that the change in character is mainly due to elevation; the woods over the higher lands having been preserved, whilst the lower lands have been taken into cultivation. It is in Great Comp Woods that we first meet with an elevation of 500 feet; the highest point there is 550 feet.

The Folkestone Beds come on generally with a slight rise of ground; this is particularly well marked at Ightham, where the

high ground is crowned by a fine Roman Camp. The two or three square miles of Folkestone Beds between Ightham and Seal are certainly the wildest and most beautiful of that division in Kent.

On the west of Sevenoaks the Lower Greensand escarpment attains a great height, 700 feet and more; and here for the most part its characters are well marked. The slope is steep until the outcrop of the Atherfield Clay is reached, beyond that it is more gentle, changing gradually into the tamer country of the Weald Clay. On the south of Westerham there appears to be a slight southerly dip, which has occasioned landslips at various times.

The Hythe Beds from Sevenoaks westwards to Limpsfield are much covered with wood.

The sandy Folkestone Beds often weather into small conical hills having much the appearance of Tumuli. This form of hill is well seen near Addington. The Lower Greensand range of Kent, and more particularly the higher ground of the Hythe Beds, is sometimes called the "Quarry Hills;" sometimes the "Red Hills," the Chalk range being then called the "White Hills."

From Limpsfield westwards to Dorking the outcrop is narrowed, and the scenery somewhat tamer than usual. At Tilburstow Hill it is more varied; here the escarpment attains the height of 590 feet.

Over the Hythe Beds drainage is easily effected. Generally, no artificial drains are necessary, but where, from the retentive nature of the surface soil, drainage is required, the water is conducted into the ragstone and disappears at once.

The following description of the Hindhead and Leith Hill districts is from the pen of Mr. Drew:—

"At the south-western corner of the district this division has a fine bold escarpment, and the whole of Hindhead Common is high ground, the highest part being 894 feet above the level of the sea; from this point the ground slopes northward, southward, and westward, and the dip of the beds is much the same as the slope of the group. The above lines of the slope must be taken as a general statement only; for the plateau, if it may be called so, is cut into by many deep valleys leading away in many directions from the summit; amongst these is the remarkable 'Devil's Punch Bowl,' a wide round-headed hollow about 300 feet deep, so that it reaches down to the Atherfield Clay, as is proved by the many springs that rise at the bottom.

"The Bargate Stone country, around Godalming, is somewhat different. From Compton to Pepperharrow and Godalming, and further to the south, it is a table-land at a level of more than 300 feet above the sea; the soil, which is moderately light, is more fertile than that of the Folkestone Beds above, from the presence of calcareous matter and the absence of oxide of iron; it is often called a 'Bargate soil.' On this plateau there is here and there some higher ground, always formed by an outlier of the Folkestone Beds, as at Farley, Munstead, and Highdown Heaths; and it is cut into by steep-sided valleys or gulleys. From Pepperharrow to Godalming the River Wey flows through a wider valley,

with a strip of flat grass-land at the bottom, bounded by high wooded banks. On all sides of Munstead Heath are valleys which by degrees get quite deep, but many of which have no stream. The valley which begins in the gap through the escarpment south of Hascombe is joined by many of these dry valleys, widens northward, and opens into the flat at Bramley. The table-land is bounded on the south and east by an escarpment, the slope of which on the east is, like that of the valleys, steep at the upper part, where the stony beds crop out, but less so for the lower half of the sand, and is much more fertile from the beginning of the clay; the ground soon sinks into the plain of the Weald Clay. The height of this escarpment above the level of the sea is 450 feet east of Thorncombe Street, and 500 or more at Hascombe Hill (where "Telegraph" is engraved on the map), 200 or 250 feet being made by the sand-beds. Westward, at Hambledon Heath, the escarpment is lower and less steep.

"The nearly flat tract taken up by the outcrop of the inliers of Atherfield and Weald Clays, south of Guildford, is bounded on all sides by an escarpment of Lower Greensand, with an average height of 200 feet above the plain. From Bramley to Compton the escarpment is formed of the Hythe Beds only; but in other parts has a capping of the ferruginous sands of the Folkestone Beds. The sketch (fig. 53) is a view of the hills from Shalford to St. Martha's, as seen from Peasemarsh; at the very top are the Folkestone Beds; the steep brow beneath is made by the Bargate Stone; and a little above the base is the outcrop of the clays which underlie all the level ground in front. The hills here are higher than round other parts of the Weald Clay inlier; the furthest one, on the top of which is St. Martha's Chapel, being nearly 600 feet above the level of the sea.

Fig. 53. View of the Lower Greensand Escarpment, from Shalford Woods to St. Martha's; seen from Pease Marsh, looking north and north-east.

"From the escarpment at Hurtwood and Leith Hill Commons, the ground slopes northward at about the same angle as the dip (2° or 3°). The summit of this ridge reaches to the great height of 900 feet above the level of the sea; one point, at the tower on Leith Hill being as much as 967 feet, higher than anything else in the south-eastern counties, Surrey, Kent, and Sussex. The rocks in this tract being sand and sandstone, without calcareous matter, make a poor soil, and the greater part is common-land, covered with heath and fir. The face of the escarpment is a steep slope for about 200 feet from the top, when clay crops out and at once changes the character of the surface; springs flow out at the junction, the land is either enclosed as fields or covered with oak (the line between the sand and the clay being most clearly marked by this change), and the slope of the ground is less, though it continues to fall for a good way into the Weald district. The sketch, fig. 54, shows the form of these hills.

"There are a few gaps in the escarpment, and the slope on the north is cut into by many narrow valleys; some, near Leith Hill, reaching down to the Atherfield Clay, which throws out a number of springs, whilst the other valleys are dry."

The Folkestone Beds form an exceedingly sterile soil, especially where they spread over a wide tract or make high ground. The projecting mass of Albury Heath, and the outliers of Black Heath and Farley Heath, will illustrate this.

Over the great area occupied by this division, south-east of Farnham, the ground is irregular in shape, rising into low hills. Crooksbury Hill, however, is higher than the rest, and makes a prominent object in the landscape. The conical hills already mentioned as occurring on the Folkestone Beds are well seen at the Devil's Jumps, south of Frensham.

The Wey varies the scenery of this country. Flat alluvial meadows border the river, and from them the sandy banks often rise with considerable steepness. Waverley Abbey is situated on the alluvial flat, surrounded on three sides by the Wey.* All around the Folkestone Beds have their usual sterile character, yet the monks are said to have found use for about 30 ploughs.†

The following remarks, by MR. C. J. A. MEYER,‡ will show the poverty of the Folkestone Beds in land shells:—

"Wherever these sands occupy the present surface of the ground, Mollusca—*Helix*, *Pupa*, &c., are rarely to be seen. And this is the more noticeable, as recent Mollusca, both of land and fresh-water species, are otherwise extremely abundant in the vicinity of Godalming; their distribution appearing, however, to be more dependent upon the nature of the soil than on that of the prevailing vegetation. Of land shells no less than 41

* Waverley was the first Cistercian House in England; its situation, on an alluvial flat, surrounded by banks, well illustrates the localities preferred by this Order. The sites of Rievaulx and Fountains are similar to this, but are far more beautiful.

† REV. A. HUSSEY, *Churches of Kent, Sussex, and Surrey*, p. 328.

‡ *On the Lower Greensand of Godalming.* A paper read before the Geologists' Association, Dec. 1868.

Fig. 54. View of the Leith Hill range, as seen from Hascombe, looking north-east and east.

species occur in this neighbourhood. Of these *four* species—*Helix pomatia*,* *H. caperata*, *Zonites purus*, and *Balea perversa*—appear to be confined to the Chalk; 32 species occur almost equally on the Chalk and on the outcrop of the Bargate-stone; two species—*Zonites excavatus* and *Helix fulva*—I have found only on purely sand-beds, and one species, *Azeca tridens*, on the outcrop of the Atherfield Clay. While, therefore, the number of *shell-bearing* Mollusca now living on the soils formed by the Chalk and Bargate-stone respectively is nearly equal (the preponderance being in favour of the latter), the outcrop of the *intermediate* sand-bed is found to be characterised by their almost total absence; and it would be useless to search for specimens on Highdon Hill to the south of Godalming, or on Crooksbury Hill, near the western extremity of the Hogsback, or on any of the wide heaths or moor-lands towards Hindhead, where the Carston beds cover the surface. I may also observe that the small streamlets which rise among these sand-beds are almost equally destitute of Mollusca."

The poverty of the soil overlying the Lower Greensand of West Surrey might be inferred from the small amount of mineral matter which the rocks yield to water passing through them (see Analyses on p. 355). It is also worthy of remark that the waters of the Wey, which drains the great sandy area, are much less suited for irrigation, and form less fertile meadows, than do those of the Mole.† The inferiority of the meadows may be chiefly due to the great quantity of *sand* carried down by the river, but the same result is observed throughout the whole course of the river. The Wey traverses only 1 mile of Chalk land, whilst the Mole passes over some 3½ miles;‡ it partially sinks *into* the Chalk for a short distance, rising again in powerful springs well charged with bicarbonate of lime.

The Folkestone Beds rise into rather high land at Woolmer Forest, and then fall again with a much narrowed outcrop towards Petersfield, where most of the land over this division is under cultivation; but from Petersfield, eastwards through the greater part of Sussex—as far in fact as the distinctive features of the Lower Greensand divisions are preserved, there is one long succession of heaths and commons. The escarpment of the Folkestone Beds, overlooking the lower ground of the Sandgate Beds, is exceedingly well marked in many parts.

The Sandgate Beds of Sussex contain more sand than do those of Kent, so that in many places their soils are quite light and poor. But there are also places where the soils are very stiff; these are where the shale beds underlie the surface. In Sussex then, we have both very stiff and very light soils over this

* *Helix pomatia* is abundant on the Chalk Downs of Surrey, particularly between Merstham and Dorking. It was introduced there from Italy to be eaten in cases of Consumption, it is said with great success. See LOVELL REEVE'S *Land and Fresh-water Mollusca*, p. 62.—W.T.

† See STEVENSON'S *Agric. of Surrey*, p. 61.

‡ In a straight line; nearly double this along the windings.

division, whilst in Kent the soils are decidedly heavier than are those of the adjoining divisions.

The Hythe Beds form the best Lower Greensand soil of Sussex, especially in their upper part, where the calcareous beds occur; here too the height is never very great. Towards the escarpment, however, the ground attains considerable elevations, and the rocks consist of sand and sandstone; here the country is less fertile. Some of it is unenclosed, and there is in places a good deal of woodland.

In Sheet 5, where the Lower Greensand is thin and its subdivisions no longer apparent, the feature it makes is small and unimportant; but its soil is very strongly marked off from that of the stiff Gault and Weald Clay adjoining. It is light, and as a whole, fertile.

The Atherfield Clay cannot be said to have any features of its own. It resembles the Weald Clay in this particular; and the change of feature comes on with the Hythe Beds. It differs from the Weald Clay however in its fertility, which has been thus described:*—

"There is a very narrow belt of land running along the escarpment of the Rag-stone, provincially called *Coomb* (the débris of the Greensand, connecting it with the Weald Clay below), which, although of a very heavy and adhesive texture, is astonishingly productive in hops, fruit, and grain. This land is sometimes so wet and stiff as to set the operation of ploughing at defiance; draining it however, will materially alter its character, and this method of improvement is being extensively practised. The natural fertility of this soil is owing to its happy mineral composition and the large amount of calcareous matter it contains."

The Gault occupies only a narrow band of country, and forms a hollow or longitudinal valley between the Chalk or Upper Greensand escarpment and the outcrop of the Folkestone Beds. Its elevation above the sea varies very considerably, rising from the river valleys towards the watersheds; but the rise is so gentle that the valley is apparently flat.

The largest area of Gault, and the district at which it attains its greatest height, is that of Alder Holt, on the south-west of Farnham. The meaning of "Alder Holt" is doubtful. "Holt" is a wood; but Oak, not Alder, is the characteristic wood of the district. This is the spelling of the Ordnance Maps, but sometimes it is written Alice Holt.

GILBERT WHITE says: —"As the parish still inclines down towards Wolmer Forest, at the junction of the clays and sand, the soil becomes a wet sandy loam, remarkable for timber but infamous for roads [Gault]. The oaks of Temple and Blackmore stand high in the estimation of purveyors, and have furnished much naval timber; while the trees on the freestone [Upper Greesand] grow large, but are what workmen call *shakey*, and

* BUCKLAND, The Farming of Kent, *Journ. Roy. Agric. Soc.*, vol. vi. p. 279, 1845.

so brittle as often to fall to pieces in sawing. Beyond the sandy loam the soil becomes an hungry lean sand [Folkestone Beds] till it mingles with the forest; and will produce little without the assistance of lime and turnips."*

"One thing is remarkable, that though the Holt has been of old well stocked with fallow deer, unrestricted by any pales or fences more than a common hedge, yet they are never seen within the limits of Wolmer; nor were the red deer of Wolmer ever known to haunt the thickets and glades of the Holt."†

A very large proportion of the Gault is in pasture, but when brought under the plough it makes an excellent soil, though very stiff and heavy; it is often known as "Black Land." Oaks grow to a large size on this clay soil. MARTIN says, "the *picturesque-traveller* who descends into the New Woods, (galt of Bury and Bignor), in a fine spring morning, will suppose himself already in the depths of the weald, for nowhere else are the roads so execrable, the oaks so thick, and the nightingales so numerous."‡

The Gault valley of West Kent and the adjoining part of Surrey is known as the "winding vale of Holmesdale;" and the term is now, I think, confined to that district. Old writers seem to have used it in a much wider sense. NORDEN speaks of "the Welds of Kent, Sussex, and Surrey, which were all anciently comprehended under the term of *Holmes dale*."§ In a map in the Lansdowne MSS. (British Museum), Holmes dale is marked in two places within the Weald.‖ "Boord's Hill, in Holmsdayle, in Sussex" (Board Hill, near Cuckfield), is supposed by some to be the birthplace of DR. ANDREW BORDE, the original "Merry Andrew."

Upper Greensand.—This division, from its thinness, has no distinctive feature of its own throughout the north-eastern tract of the Weald. It is not until we reach the neighbourhood of Godstone that it has any effect upon the scenery. Here it runs out from below the Chalk escarpment in a well-marked terrace, the northern slope of which nearly corresponds to the dip of the bed, whilst the southern face is sharply cut. It is in fact a very well-marked escarpment.

Fig. 55. View of the Malm Rock Escarpment at Hartley.¶

This character more or less attends the Upper Greensand throughout its range in Hants and Sussex, but through a good

* *Nat. Hist. of Selborne*, letter I.
† *Ibid*, letter IX.
‡ *Western Sussex*, p. 47.
§ *Surveyor's Dialogue*, p. 214, 1607.
‖ There is a farmhouse called Holmes Dale 1½ miles north of Fletching, Sussex.
¶ A sketch by MR. DREW from *Geol. Survey Memoir*, Sheet 12, p. 5.

part of Surrey the high dip of the beds near the Chalk escarpment prevents the Upper Greensand from assuming its characteristic features. The escarpment is perhaps best seen in the country around Selbourne, where the scenery has been described by GILBERT WHITE.

Figs. 55 and 56 will serve to illustrate the form of the ground hereabouts.

In Sheet 5 the escarpment is less strongly marked, the Upper Greensand being there for the most part composed of soft beds.

Fig. 56. View of the Chalk and Malm Escarpments near Petersfield, seen from near Steep Church.

Near Selbourne the face of the Upper Greensand escarpment is often exceedingly steep, and where so, it is generally covered with wood. Such steep and wooded slopes are called *hangers*. The term is especially characteristic of the Selbourne district, but is used elsewhere in the Weald. I have heard it as far east as Tenterden.

The following extract is by MR. BRISTOW :—*

"One of these hangers is situated on the Chalk immediately behind and overhanging the village of Selbourne on the western side, and another of greater extent, marked Milkwell Wood on the Map, occupies the position of the lower escarpment of the Upper Greensand, immediately adjoining its junction with the Gault. The surface of the ground along the boundary of these two formations is very irregular and broken, for the springs thrown out by the Gault render the clays of that formation so unctuous and slippery as to produce a tendency on the part of the overlying beds to founder and slide over it, especially after seasons of more than ordinary wetness. This is especially observable in the east side of the hanger marked Milkwell Wood on the Map, where

* *Mem. Geol. Survey*, Sheet 12, p. 7. See Chap. XVII. for a further account of this landslip.

extensive founderings of the higher beds have occurred in this manner nearly a century ago, the effects of which can be clearly traced in the tumbled and uneven surface of the ground on either side of the road from West Worldham to Milkwell."

MR. MARTIN * remarks upon the Upper Greensand terrace of West Sussex, "that it is broadest on the eastern side of every remarkably salient angle of the Chalk. Accordingly, the broadest exposure in this part of the country is between Sutton and Bury, under shelter of the projecting hills of Duncton and Sutton."

In fertility the Upper Greensand takes precedence of all formations within the Weald; everywhere it is largely laid out in arable fields, only a small proportion is in grass, still less in woods, this being chiefly along the steep faces of the escarpment. Probably there is scarcely an acre of truly waste land on the whole extent of the formation.

The stiffest land upon the Upper Greensand is that nearest the foot of the Chalk escarpment, along the outcrop of the green marly sand. This bed of greensand forms an extremely rich soil, but generally it occurs only as a narrow band or "vein," running across the fields.† The lower slopes of the Chalk Marl also give a rather stiff soil. The soil of the plateau is generally "stony," from the decomposition of the malm rock; but it requires draining in some places.

The fertility of the marly sand is chiefly due to the large proportion of phosphate of lime which it contains. This substance is generally diffused through the Upper Greensand; many beds in the malm rock contain much "soluble silica." ‡

All agricultural writers who have described the soil of the south-east of England have highly praised those of the Upper Greensand. Perhaps I cannot do better than select a few extracts from some of them.

One of the oldest is GILBERT WHITE, who, in his general description of Selbourne (Letter I.), writes as follows:—

"The houses are divided from the hill [Chalk escarpment] by a vein of stiff clay, (good wheat land,) [marl of the Upper Greensand], yet stand on a rock of white stone, little in appearance removed from chalk [malm-rock, firestone]; but seems so far from being calcareous, that it endures extreme heat. Yet that the freestone still preserves somewhat that is analogous to chalk, is plain from the beeches, which descend as low as these rocks extend, and no farther, and thrive as well on them, where the ground is steep, as on the chalk."

"To the north-west, north and east of the village, is a range of fair enclosures, consisting of what is called a white malm, a sort of

* *Western Sussex*, 1828, p. 20.

† "There is a very striking illustration of the effect produced by a narrow band of the green marl which runs through a field of wheat now growing at the N.E. extremity of the parish (Farnham). The strata here are nearly vertical, and the band is very thin, so that its direction across the field may be traced by a rank green luxuriant belt of wheat about six feet in width." PAINE and WAY, on the Phosphoric Strata of the Chalk Formation. *Journ. Roy Agric. Soc.*, vol. ix. p. 67.

‡ See Analysis and descriptions of the Upper Greensand Manures, on pp. 388 and 391.

rotten or rubble stone, which, when turned up to the frost and rain, moulders to pieces, and becomes manure to itself." "This soil produces good wheat and clover."

"Still on to the north-east, and a step lower, is a kind of white land, neither chalk nor clay, neither fit for pasture nor for the plough, yet kindly for hops, which root deep into the freestone, and have thin poles and wood for charcoal growing just at hand. This white soil produces the brightest hops."

The REV. J. WILKINSON thus reports on the Wealden district of Hampshire :—*

"Though the cultivation of the hop lends the chief interest to this portion of the country, yet it is remarkable also for its other agricultural productions, being by nature the most fruitful part of Hampshire. From the hill above Alton, on the road to Odiham, you can see the whole of it, from Holybourne, Foyle, and Binstead, to Nore and Selborne Hills, Newton Common, and Petersfield. At Holybourne wheat and beans are taken alternately on the strong land; but this country is very subject to charlock, which cannot be kept down under this rotation, so that the four-field is the more usual. It is both a breeding and a grazing district. The are some rich and dry meadows on the greensand about Kingsley, East and West Worldham, and Hartley; the grass, however, is hardly sufficient to make out the beasts, which are generally stalled afterwards. . . . . The produce of this district is: wheat, 36 bushels; beans, 30; oats, 8 or 10 quarters; barley is not much grown. Farnham, Alton, and Basingstoke are the chief markets."

MR. MARTIN states that the malm rock of Sussex is "particularly "favourable to the growth of the apple and walnut, which find "rooting upon its barest rocks."

Hops have long been the characteristic crop of the Upper Greensand in West Surrey, West Sussex, and Hants; those of Farnham being especially celebrated.†

Chalk.—It forms no part of the plan of this Memoir to describe the Chalk; that, for the north of the Weald, has been done by MR. WHITAKER in the Memoir on the London Basin; but it is impossible to pass over without comment the great feature of the Chalk escarpment, which forms so natural a boundary to the Wealden district.

Fig. 57 is a view of Mount Caburn, east of Lewes;‡ this is an isolated hill of Chalk lying in a synclinal, as is shown in the section (fig. 43) on p. 227.

The Frontispiece to this Memoir shows the shape of the escarpment near Folkestone.§ The highest part is formed of Chalk-with-flints, the central part of Chalk-without-flints, and the lower

* The Farming of Hampshire, *Journ. Roy. Agric. Soc.*, vol. xxii. p. 306.

† The Upper Greensand of Oxfordshire is remarkable for the great quantity of *wild* hops which grow upon it. C. S. READ, Report on Oxfordshire, *Journ. Roy. Agric. Soc.*, vol. xv. p. 195.

‡ From a drawing by LAMBERT, in the BURRELL MSS., British Museum.

§ From a drawing by MR. FRANK RUTLEY, F.G.S. The figs. on pp. 165, 177, 194, 226, 227, 230, 231, and 233 show the *outline* of the Chalk escarpment at various points.

Fig. 57. View of Mount Caburn, near Lewes.

and gentler slopes of Chalk Marl. The lower slopes pass with a continuous curve into the flatter ground occupied by the Gault, for, as already stated, the Upper Greensand makes no feature in Kent. The crest of the escarpment is *everywhere* the highest ground attained by the Chalk in that district; and from the crest the ground slopes gradually away towards the Tertiaries, at an angle slightly less than that of the dip of the beds.

The face of the escarpment is not a continuous *straight* line, but it winds about slightly, projecting into what have been called "capes" or "headlands," and curving backwards into what have been called "bays;" so that in looking along the line of escarpment we do not see an unbroken wall of Chalk, but a series of convex curves, hiding from view the intermediate concave curves.* At the foot of the escarpment there are frequently springs, some of them of considerable power. These do not break out at the prominent points of the escarpment, but in the receding curves. Where these curves indent the escarpment deeply they are called "Coombs." As a rule, the deeper and more strongly marked the coomb, the stronger is the spring which it contains.

Although the absolute height of the crest of the escarpment above the sea varies considerably in different parts of the Weald, yet the height of that crest above the outcrop of the Upper Greensand is tolerably uniform. As the crest of the escarpment rises towards the watersheds, so does the lower ground at its foot.

The Chalk escarpment is interrupted in several places by valleys of two sorts. There are the large transverse valleys through which the rivers run, and there are smaller breaks or "passes." These passes leads into valleys which are now mostly dry; but if they carried streams, as formerly no doubt they did, and as some of them do still after wet seasons, they would not drain any of the interior of the country. They merely notch the escarpment without absolutely breaking it.

The Chalk escarpment has a far more uneven outline throughout Sussex than it has on the north through Kent and Surrey. On the north of the Weald the crest of the escarpment forms a very uniform flat, inclining only with an almost imperceptible slope towards the transverse valleys, and broken occasionally, but rarely, by passes. The neighbourhood of Folkestone is an exception to this rule (see frontispiece).

Very rarely do we find the crest of the southern Chalk escarpment forming a flat surface, but it has a waved, undulating outline. The hollows are not always deep, but sufficiently so to make walking along the edge of the escarpment a tiring though pleasant task.† Generally the edge of the escarpment is quite bare of any super-

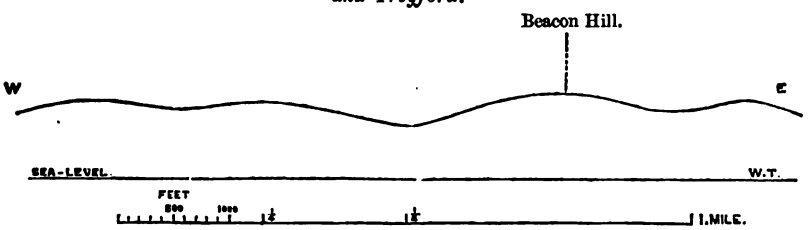
* See Mr. A. Tylor's paper (*Geol. Mag.*, vol. ix. p. 500) for some remarks upon the curves of the Chalk escarpment.

† There is no term in common use among geologists or geographers that I know of to express such hollows as those. Mr. G. A. Lebour has proposed to use the Northumbrian word *swire* (*Geol. Mag.*, vol. vi. p. 443). The word is thus defined by J. T. Brockett:—"Swire, swyre, the hollow or defile near the summit of a hill." (Glossary of North-country Words, 3rd ed.) Some such term is very much needed, and this perfectly meets the case. A swire is a "pass," but on a very small scale; its sides are never very steep.

ficial covering; but if, as is the case in Kent and Surrey, there were a covering of clay-with-flints, a drift map showing this would give a succession of small outliers, whereas, on the north of the Weald, this clay-with-flints often caps the escarpment uninterruptedly for several miles.

Fig. 58 will serve to show the irregular outline of little more than a mile of the South Downs. It is constructed from aneroid observations made by myself. It is unnecessary to draw an equal length of the North Downs for comparison; this, on so small a scale, would generally be represented by a straight line.

Fig. 58. Outline of the Crest of the Chalk Escarpment, between South Harting and Treyford.



Scale (vertical and Horizontal), 3 inches to 1 mile.

The reason of this difference appears to be that the southern escarpment shows a later stage in the denudation of the district than does the northern escarpment. In the latter the escarpment itself is retreating northwards; and the long dry valleys which cut into the chalk plateau, have not yet met the escarpment in wearing themselves southwards. If denudation goes on a little further the escarpment will meet (and be notched by) these valleys. This seems to be the condition of things which now exists on the south.

There is, however, a further distinction between the northern and southern escarpments. If anywhere in West Kent or Surrey we stand at the crest of the escarpment and look northwards the plateau is seen to fall very gradually in that direction, and there is no rise of ground until we reach the Lower Tertiaries which sometimes come on with an escarpment.* In Sussex, on the contrary, there is a well-marked line of hills running parallel with the escarpment. These have their steepest faces on their northern sides, whilst the dip is to the south, as at the escarpment. We may therefore consider these hills as representing, and being the remains of, a second and outer Chalk escarpment. Fig. 42 (p. 226) is a section taken through one of these hills.

This old escarpment is not apparent on the east of the River Adur, unless the hill marked White Lot represents it, as probably it does; but this is less than two miles from the river. Still further to the east there is an escarpment-like hill on the south of

* In East Kent there is a second Chalk escarpment, which is plainly marked near Canterbury. See the description of this escarpment by Mr. W. Whitaker and Prof. T. McK. Hughes in *Mem. Geol. Survey*, vol. iv. p. 366.

Stanmer Park, which, after a break, is continued to the east by Newmarket Hill and the high ground south-west of Kingstone. Here the hill curves to the south-east, and is plainly the same feature as that on the east of the Ouse which runs direct to Firle Beacon, and there becomes the normal Chalk escarpment. These features, however, are probably not a second and outer escarpment, but are the true escarpment repeated and thrown back by the Greenhurst anticlinal (see fig. 43, p. 227). This anticlinal in its passage to the west leaves the Chalk at Piecomb; therefore the outer escarpment to the west, now to be described, has nothing to do with it.

Taking, then, White Lot as its probable eastern limit, this old escarpment can be very plainly traced westwards through the following points:—Steep Down, Cisebury Hill, Blackpatch Hill, Harrow Hill, the hill one mile north-east of Burpham, Nore Wood, Rooks Hill, Bow Hill (its northern side), Idsworth Down, Charlton Down, Catherington Down, and Broad Halfpenny Down. To this point, which is as far west as I personally know the Chalk country, the line is most distinctly marked. Beyond this it might go by Old Winchester Hill or Stoke Down, across the River Titchfield to Stevens Down; or it may take the more northerly line of heights to Beacon Hill and Kilmerton Down. Probably, however, it cannot be traced across the broad expanse of the Hampshire Chalk.

The face of the Chalk escarpment is almost everywhere covered with a short close turf, the slope being fortunately too steep to allow of arable culture. Here and there are straggling patches of wood which add to the beauty of the landscape. The tree which above all others especially characterises the Chalk is the Beech; but the Box, the Yew, and the Juniper also grow well there.

The lower slopes are everywhere under the plough, and produce an excellent soil.

Bas Boulonnais.—A few words upon the features of the Lower Boulonnais will appropriately close this chapter.

The Chalk escarpment, which commences on the coast near Wissant, extends all around the district to Neufchatel. Here it terminates two miles from the sea, the intermediate space being occupied by sand-dunes. The three chief rivers are the Slack and the Wimereux on the north, which are probably tributaries of the ancient Rother, and the Liane on the south, which we have already considered as the sixth southern river of the primeval Weald. The central line of elevation traverses Mont Lambert (the highest point in the interior of the country), 617 feet high; an elevation rather exceeding the *average* height of the Chalk escarpment.

The following are some heights (in feet) along the crest of the escarpment:*—Mt. Couple, near Wissant 534; Landrethun-le-

* Taken from the French Government Map, on which the heights are expressed in mètres.

Nord 393; east end of the Forêt de Guines 534; Boursin 584; end of Chalk spur wast of Boursin 380; Signal de Colembert 666; Mont Hulin, near Desvres 679; south of Long-Fosse 695; Mont Violette, near Verlincthun 594.

The Chalk plateau is much covered with drift (Clay-with-flints, &c.), and where this is the case there is a good deal of wood. The largest piece of woodland is the Forêt de Guines.

The slope of the escarpment is mainly in down-land, but in some places it is dotted over with straggling woods, strikingly recalling the Chalks hills of Boxley and Dorking.

At the base of the Chalk there is the Gault valley, presenting much the same characters as in the Weald, but of less width. The Upper Greensand is too thin and soft to make a feature, but it, together with the lower slopes of the Chalk, forms an excellent soil.

The Lower Greensand, of which probably only the upper sandy division (or Folkestone Beds) is represented, forms a low range of hills rising with a gradual slope from the Gault valley, and ending generally with an escarpment facing the central country. This escarpment, which is well seen on the south between Desvres and the Forêt d'Hardelot, is less regular in outline than that of the Lower Greensand in the Weald. The reason is that the streams which rise at the foot of the Chalk escarpment run directly across the Gault and through the Lower Greensand, thus carving the latter into a succession of hills and small transverse valleys. In the Weald the streams from the Chalk very frequently run for some distance along the Gault, or flow into longitudinal valleys which run in the Lower Greensand country. The beds are so thin in the Boulonnais that we cannot expect the same behaviour from the streams as in the Weald.

The Wealden Beds on the borders of the Boulonnais do not form a country distinct from the Lower Greensand. The mottled clays, sands, and ironstones of which they are composed form a poor soil. The poverty of the Wealden soils is much more forcibly shown on the outliers of that formation which dot the interior of the country. Here there is but little clay, the rocks consisting almost wholly of sand, sandy ironstone, and loose pebbles or soft conglomerate. Capping as they do the highest hills, and forming but an unproductive soil, they are well suited for military operations. Most of the fortifications around Boulogne are built on Wealden Beds. It was on their open and uncultivated flats that NAPOLEON I. marshalled his army, and on one of the outliers the "Colonne de la Grande Armée" is built.

Viewed from the face of the Chalk escarpment between Samer and Desvres the country presents very much the same appearance as does our English Weald. There are the Chalk and Lower Greensand escarpments, the valley of the Liane, which serves to remind us of the Weald Clay flat, and lastly the hilly country in the centre of the district. This resemblance, however, is more apparent than real, for the interior is occupied by Oolitic rocks (from the Portland to the Great Oolite). These lower formations, upon

which the Cretaceous rocks lie unconformably, have features of their own with which we are not now concerned. In the extreme north-easterly corner of the district appear the Palæozoic rocks (Carboniferous Limestone and Devonian), which give at once a very different look to the country. The steep-sided rocky valleys contrasting forcibly with the smoother slopes of the secondary clays and limestones.

In spite of these differences in detailed structure it is very probable that the greater part, if not the whole of the Lower Boulonnais was formerly, like the Weald, a thickly-wooded country. There are still considerable forests in the district. The most important are the following (beginning with the largest):—Forêt de Boulogne, Haute Forêt de Desvres, Forêt d'Hardelot, Bois de Crébert, Basse Forêt de Desvres. This last is separated from the Haute Forêt only by one of the tributaries of the Liane.

CHAPTER XVI.—DENUDATION OF THE WEALD.*

The arguments advanced in this Chapter in favour of subaërial denudation are, in the main, those employed in a paper read before the Geological Society on 24th May 1865.†

This paper (published by permission of the Director-General) was the result of three years' detailed field-work in the Weald by DR. C. LE NEVE FOSTER and myself.

We had discussed the question together so often that it is hard to say to whom the various arguments advanced in that paper belong. I wish it therefore to be understood that, although this Chapter is written by me—yet, whatever credit, if any, may be considered my due, may be duly shared by DR. FOSTER. Especially should this be the case with the *proof* herein given, from a consideration of the river-gravels, particularly those of the Medway, that an enormous amount of denudation is owing to subaërial weathering, and to fluviatile erosion by rivers flowing in their present courses.

Of the arguments used in the paper referred to, some had previously been advanced by COL. GREENWOOD, MR. JUKES, PROF. RAMSAY, REV. O. FISHER, and others; some have been proposed or have been more fully worked out since;‡ others are here published for the first time.§

Many geologists when discussing the Denudation of the Weald assume that the phenomena presented to our view within that area are anomalous in their character; hence special conditions are invoked to account for them—conditions which the proposers would hardly dream of applying universally. But, in truth, the "Denudation of the Weald," is anomalous only in its extreme simplicity.

In the first place it is necessary to inquire what is the character of the area with which we have to deal; whether the district which is termed "the Weald" be a district complete and perfect in itself, or whether it be but a fragment of a larger area. The external shape and internal structure of the district have been so fully discussed in the foregoing pages, that there is no need to re-state the facts here. It has also been shown that on the east side of the English Channel there is another denuded area, which resembles the Weald in its main characters. The question then arises,—were these two areas originally separate and distinct, as now; or were they once united?

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* I may perhaps refer the reader to the latter part of Chapter II. (commencing at p. 18), for notices of some books and papers on the Denudation of the Weald, which are not mentioned here.

† "On the Superficial Deposits of the Valley of the Medway, with Remarks on the Denudation of the Weald," by DR. C. LE NEVE FOSTER and W. TOPLEY. *Quart. Journ. Geol. Soc.*, vol. xxi. p. 443.

‡ See especially MR. WHITAKER'S paper on Subaërial Denudation. *Geol. Mag.*, vol. iv. pp. 447, 483, 1867.

§ MR. DREW, who left the Survey in 1862, had been led, from his field-work in the Weald, to reject the theory of the marine origin of escarpments.

No one doubts that the North Downs once stretched across the Straits of Dover, and joined the Chalk cliffs of France; in fact, their having done so is an essential part of some theories of Wealden denudation. But all the arguments which may be used in favour of the northern Chalk escarpment having formerly stretched across the Channel, hold equally good in favour of the southern Chalk escarpment having done the same. The fact that the former union of England and France is assumed to have been by the North Downs solely, can only be explained by this other fact, that to have prolonged both North and South Downs across the Channel would have been fatal to most of the denudation theories.

If the North and South Downs were both continued across the Channel, the Wealden district of England would be continuous with the Lower Boulonnais, and there would be a *closed area*, surrounded everywhere by the Chalk escarpment, and sometimes by other lines of escarpment within that; these escarpments being interrupted only at the narrow river valleys.

It cannot be said that this is an improbable supposition. There are other anticlinal, or rather periclinal, areas, similar in all respects to this ancient Weald, and in which the surrounding escarpments are continuous, breached only by the transverse valleys which drain the enclosed area. There is the Pays de Bray, which exactly resembles the Weald, exposing within its area similar Lower Cretaceous Beds, and bounded by a like escarpment. It differs from the Weald only in its smaller size, and in the fact that it is *entire*, not truncated by the coast line. Another well-known example is the valley of Woolhope, surrounded by concentric escarpments which are breached by a transverse valley. The Upper Greensand inliers of Shalbourn and Kingsclere are other and smaller examples.

We are then justified in assuming it to be possible, or rather to be highly probable, that the Weald, like these other anticlinal areas, was once a *closed area*. Any theory which may be put forward to explain the denudation of the Weald as it now is, should be equally capable of explaining the denudation of that area as it once was, or may have been. Certainly it should be able to explain the denudation of the Pays de Bray, Woolhope Valley, and other like areas. If it cannot do this we are justified, not perhaps in rejecting it, but at least in regarding it with grave suspicion.

The Map, Plate II., shows the Wealden area restored. The exact positions of the central anticlinal and of the missing rivers and escarpments are of course only matters of conjecture.* It is likely that the central line of the Boulonnais would not join that of Fairlight; but that these two lines would die out and be replaced by

* The dotted lines on the Map are taken from the extremities of the existing escarpments, as the only means of showing the facts acquired. But it must not be supposed that before the Straits of Dover were formed, the escarpments occupied their present positions; the North Downs were then probably further south than now. The breaching of the South Downs probably took place at a still earlier date, and this escarpment would then have stretched much further to the north.

each other, just as the Crowborough, Brightling, and Fairlight lines do. It has been shown that the streams of the Rother are wholly of the north of the central line, as are also those of the Slack, Wimereux; these would therefore be the higher branche[illegible] which breached the Chalk escarpment where are now the Str[illegible]t Dover. Whether there were two rivers on the south, corresponding to the Stour and Rother, or only one, we cannot tell. But looking to the very striking correspondence which there is between the four southern rivers and four of those on the north, it is likely that there were two others on the south. The outlet of the most westerly of these (the Ashburn) would probably have been only a few miles east of Beachy Head, the other (the Liane) nearly in mid-channel.

It may be well to note that the possibility of there having been a river flowing from the Weald through the "Straits of Dover" has an important bearing upon certain arguments for the late date of the opening of those straits, grounded upon the presence in the old Sangatte beach of pebbles from the Lower Greensand. MR. PRESTWICH has noticed this, and he says:*—"I have evidence to show that in the very centre of the Wealden area there are remarkable cases of valley-excavation and old river-action. I have even there found beds of high-level gravel. Now these rivers, in their passage across the lower Greensand, always took up considerable quantities of chert and ragstone fragments, which they carried out into the valleys traversing over North Downs and into the valley of the Thames. It is therefore possible that somewhere between Calais and Dover there may have been an old river flowing eastward from the Wealden area, and debouching in this part of the English Channel, into which it might have transported the chert and other pebbles we find in the beach at Sangatte. I am disposed, however, to consider the transport by sea-action along a channel open from west to east, as at present, although much narrower, the more probable."

The theory of denudation which the Officers of the Geological Survey engaged in mapping the Weald have been led to adopt, is that of long continued subaërial action on an ancient "plain of marine denudation." This theory, it is the object of this chapter to illustrate, and, I hope, to prove.

Briefly stated, it is as follows†:—"One great effect of marine denudation when prolonged over periods of enormous length, is to produce extensive plains . . . . . for, the result produced by the wasting power of breakers is to *plane off*, as it were, the asperities of the land, and reduce it to its own average tidal level." "The sea waves on the cliffs by the shore are the only power I know that can denude a country, *so as to shave it across* and make a plane either horizontally or slightly inclined." "If such

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* *Quart. Journ. Geol. Soc.*, vol., xxi. p. 442.

† The following extracts are from PROF. RAMSAY'S Physical Geology and Geography of Great Britain, 2nd edit., 1864, pp. 80–83, 141; (see also p. 113 of 3 Ed., 1872).

plain once existed [in the south-east of England], it is easy to [illegible]d how the rivers might in old times have flowed from [illegible]al watershed to the north and south across the top of [illegible] elevations at least as high as, and perhaps even a lit[illegible]gher than the present summit-levels. Thus, as by their action the general level of the *inner* country was being partly reduced, they would cut north and south channels through the chalk downs as we now see in the Stour, the Medway, the Dart, the Mole, the Wey, which run athwart the North Downs, and the Arun, the Adur, the Ouse, and the Cuckmare, which, through gaps in the South Downs, flow south. . . . . After the formation of the marine plain, the Chalk being comparatively hard has only been partly denuded, and now stands out as a bold escarpment in the Downs. The soft clay of the Gault has been more easily worn away, and forms a hollow or plain. The Lower Greensand, full of hard bands, and ironstone, more strongly resisting denudation, forms a second range of scarped hills overlooking the more easily wasted Weald Clay, which forms a second broad plain, from under which rise the harder sub-divisions of the Hastings sands, forming the undulations seamed by brooks of the central hills of Ashdown Forest, and other places. The absence of flints over nearly the whole of the Wealden area, excepting near the Downs, is easily explained by this hypothesis, for the original marine denudation had removed all the Chalk, except near the margin, long before the river denudations which commenced the escarpments began."

COL. GREENWOOD's explanation of the theory is as follows *:—

"A stream running *through* ridges, large or small, is the simple consequence of the differing hardness of the ground through which it runs. In all cases a stream cuts for itself a narrow channel, *the depth of which is determined by the hardest part.* For a stream cannot run down where its bed is soft, and up again where it is hard. But the wash of rain digs down where the ground is soft, and leaves hills or ridges where it is hard. And as a stream cuts through a hard stratum, say the North or South Downs, the wash of rain is scooping out two lateral valleys *behind* it, that is, a valley behind each side of the gorge and ridge, as in the Weald Clay. . . . .

"The ridges thus, instead of being considered as barriers to the river, have been actually *formed* by the river by the abstraction of intervening masses. . . . .

"The height of some of these ridges, though a *proof*, is a very inadequate *measure* of the enormous denudation which has gone on *behind* them, since the ridges themselves have suffered enormous denudation. The tops of all such ridges must originally have been lower than the hills from which the rivers rise. But whether all or any of them continue lower, and their comparative height one with the other, will depend simply on which is the hardest, that is, which is most quickly disintegrated and denuded;

* *Rain and Rivers*, Chap. III. This book was first published in 1857; the extract here given is from the 2nd ed., 1866, p. 57–60.

the hills from which the rivers rise *might* be denuded [almost] as low as the beds of the rivers in the gorges."

The foregoing extracts sufficiently explain the general theory of subaërial denudation, but a few words may here be added on the formation of the escarpments.*

In the case of the plain of marine denudation described above, we should have a comparatively plane surface sloping from a central line to the north and south. But the beds which crop to the surface in the centre or highest part of that plain, would be geologically the lowest; and as we pass to the north or south from that central line, higher beds would come on in succession; for the dip of the beds would exceed the slope of the plain. These beds would be alternately hard and soft, as we passed successively over the denuded edges of the Hastings Beds, Weald Clay, Lower Greensand, Gault, and Chalk.

Streams would flow down this slope, probably directed into their several channels by means hereafter described (p. 278). These streams would excavate their valleys and would carry off the material which the more general subaërial agencies provided. It is to these agencies, and not directly to rivers or streams, that we must refer the escarpments.

Rain and frost acting upon the alternate hard and soft beds would soon exert an influence; and a hard bed, ending off in a thin edge along the plain, would rapidly assume a step-like form; which would be a small escarpment. This escarpment in wearing back would constantly get higher, because its base would be denuded lower.

But there is another point to consider, besides the relative hardness of the rocks. We find that escarpments are composed of *porous rocks*, whilst the plains at their feet are generally formed in *impervious rocks*. Therefore a great part of the rain which falls on the top, or dip-slope, of the rock forming the escarpment *soaks into it*, and has little or no mechanical denuding effect. But a part of this water issues as springs at the base of the escarpment, where the impervious bed occurs, and thus tends to wear back the face.

The "growth" of an escarpment depends principally upon the excess of the denudation of the face, over that of the dip-slope; and it is evident that the requisite conditions are best fulfilled, when a hard and porous bed rests upon a soft and impervious bed. But it will not wholly depend upon this. We must also consider the relation of the slope of the marine plain (roughly represented by the existing dip-slope) to the true dip of the beds. If, for a certain distance, they are the same in amount, the escarpment will not increase in height, although it will still be worn back. It will rather tend to diminish in height, because of the slight denudation which the dip-slope may undergo. If, however, the dip of

* See the paper already referred to, On the Denudation of the Weald, &c. *Quart. Journ. Geol. Soc.*, vol. xxi. p. 470. The subject is more fully discussed by Prof. Ramsay, *loc. cit.*, 3 Ed. chap. viii. and xiv. See also the same author's paper "On the River-courses of England and Wales." *Quart. Journ. Geol. Soc.*, vol. xxviii. p. 148.

the beds exceeds the slope of the ground, the escarpment, in receding, will necessarily increase in height.*

Possibly there is some relation existing between the rate at which an escarpment recedes and the dip of the beds. It is certain that there must be some relation between the amount of the dip of the beds and the slope of the face of the escarpment; but these are points requiring investigation.

Where the porous rock is limestone, another force comes into play; that is chemical action. Water which falls on the dip-slope of a sandstone country has little or no denuding power when it sinks into the rock, excepting where it comes out again as springs. But water containing Carbonic Acid percolating through limestone, continues to exert a denuding power until it has taken up its full amount of lime. This power is most strongly exerted near to the surface, and consequently the dip-slope is lowered. The clay-with-flints upon the Chalk is the result of this general lowering of the surface. But the excavation, by mechanical denudation, of the soft impervious bed below the limestone so greatly exceeds the chemical denudation of the limestone itself, that the latter still forms an escarpment.

Mr. Martin first advanced the opinion that the transverse valleys of the Weald coincide with lines of fracture. Mr. Hopkins in his well known paper went further, and attempted to show that in any area of upheaval there must necessarily be two sets of disturbances, more or less at right angles to each other; from this the further inference has been drawn, that the faults are the direct cause of the valleys. "But, if this be so, the valleys and the faults ought to coincide, not only in direction, but absolutely. This they rarely or never do.

"The longitudinal valleys run along the outcrop of the softer beds, or those most easily eroded. This of itself is some evidence of their formation by erosion. But the strike of the beds of any area necessarily corresponds in direction with its lines of disturbance, being alike due to elevatory forces acting from beneath. Hence we see that the strike and the faults are effects of the same cause; while the longitudinal valleys are determined by the strike alone, and may be seen to be so in districts where faults are altogether absent.

"Against Mr. Hopkins's mathemathical deductions we neither presume nor wish to contend. It is quite certain that longitudinal disturbances have taken place, and it is certainly possible that transverse fissures may have been formed which gave the original direction to the rivers which now run through deeply eroded valleys. Such dislocations, however, must have been mere fissures, and nothing more. There was no possibility of the beds slipping away on either side, nor has any vertical displacement taken place. Therefore the transverse valleys are still 'valleys of denudation.'

* That is to say, in relative height, as compared with the low ground at its foot; not in absolute height above the sea-level.

Moreover, it is somewhat surprising that the Geological Survey has been unable to find any very important dislocations in any other parts of the Chalk escarpment. The Gault and Greensand lines have been drawn with care, but no marked disturbances are known; nor, as Mr. Hopkins admits, is there any *proof* that dislocations of any kind occur even in the transverse valleys themselves."*

The Coombe, near Lewes, is constantly cited as an example of a valley coinciding with a line of fault; and it is as often taken as a *type* of valleys intersecting the Chalk hills; but this is manifestly erroneous. In the first place there is some doubt as to the existence of this fault, which has figured in geological manuals on the authority of DR. MANTELL. MR. BRISTOW, however, is of opinion that there is no fault here and that the dip on both sides of the Coombe from north to south is amply sufficient to carry the Lower Chalk, which appears on the north side, down below the Chalk-with-flints which appears on the south side.

But even supposing that there is a fault along this valley, and that some half-a-dozen other hollows or valleys in the Chalk range coincide with lines of fault, it surely is illogical to assume, 1st, that these valleys owe their existence to such faults, 2nd, that faults are the cause of all or nearly all valleys; when for hundreds of valleys there is not a particle of evidence for the existence of such faults within them, and for a very large majority it can be demonstrated that no fault whatever exists.

It is only necessary to refer to the published Maps and Horizontal Sections of the Geological Survey to see this. These are constructed to represent the actual structure of the country, without regard to any theory whatever, and they abundantly confirm the following statement of MR. CONYBEARE (written in 1822):—

"In a great majority of instances (ninety-nine out of the hundred at least) the strata are regularly found in the continuation of their planes, whenever and however these planes are cut by valleys. The only excepted cases are, when the direction of the valley coincides with that of a fault, or dislocation and subsidence of the strata, and these are of the very rarest occurrence."†

It is certainly singular that the transverse valleys should correspond in position on opposite sides of the Weald, as they undoubtedly do; and in the Map of the Ancient Weald, (Plate II.) they are represented with a greater amount of agreement than has hitherto been allowed. It is generally supposed that these transverse valleys coincide with transverse anticlinal fractures, but I am not acquainted with any conclusive evidence in

* FOSTER and TOPLEY, "On the Denudation of the Weald." *Quart. Journ. Geol. Soc.*, vol. xxi. p. 462, 1865. The faults which do exist along the Chalk escarpment are frequently coincident with *passes*, where the escarpment is only partially breached (see *post*, p. 278).

† *Outlines*, p. xxvi. *note*. PROF. A. GEIKIE has in various works shown the comparatively small influence which disturbances of the rocks have had in producing the surface features. See especially his *Scenery of Scotland*, pp. 97, 121, &c., 1865; and his address to the Geol. Soc. of Edinburgh, Nov. 6th, 1873.

support of this.* On the contrary, it can be shown that these transverse valleys, in some cases, coincide with *transverse synclinals.* As this is a matter which has not yet been noticed, and as it is one of some importance, I give the following evidence in support of that statement.

The Stour runs through the Lower Greensand in a transverse synclinal.

By the three cross roads north of Little Otterpool, 1½ mile S.E. of Sellinge, there is a bench-mark at the height of 242 ft. Exactly 4 miles to the west-north-west of this, at the Lodge north-east of Mersham Street, there is another bench-mark at 244 ft. As these two points are each very near to the base of the Sandgate Beds we have the true *strike* of the beds along that line. If this line be produced still further to the west-north-west it cuts the Folkestone Beds at Willesborough, but at a lower level, 70 or 80 ft. less. Adding 60 ft. for the thickness of the Sandgate Beds passed over, we have a fall in the beds of 130 or 140 ft. towards the Stour. On the west side of the Stour the beds are at first faulted, and beyond that, further to the west, there are not sufficient data available for deciding accurately the strike of the beds; but it is evident that, as a whole, they rise to the west.

When the Medway Valley traverses the Lower Greensand there is very good evidence of a transverse synclinal. The Hythe Beds are lying nearly flat, the northerly dip being very small.† At Linton the bottom of the Hythe Beds is at a height of more than 200 ft.; at Yalding the height is less than 100 ft. There is here then a fall from east to west, towards the river and *along* the escarpment, of 100 ft. or more in 4 miles. On the west of the river there is a rise along the escarpment, but its amount and exact direction are less easily ascertained. The Hythe Beds at Great Comp Woods attain a height of 550 ft., as the thickness here is little over 100 ft. the bottom is more than 400 ft. above the sea. But along the Medway Valley the bottom is not more than 50 ft. above the sea; generally it is much less than this. There is then also a fall from west to east, and the Medway consequently lies in a synclinal.

The Darent is a river rising in the Lower Greensand area, and breaching the Chalk escarpment in the usual manner. But as there are no streams from the Weald Clay flowing into it the Lower Greensand escarpment is not breached. There is here no sign of a transverse synclinal, for the 500 ft. contour keeps very near the outcrop of the Atherfield Clay.

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* There is some evidence to show that where the Medway traverses the Chalk there is a slight anticlinal, which, indeed, is partly indicated by the change of strike of the Chalk escarpment. (*See* the remarks by MR. WHITAKER and PROF. T. McK. HUGHES, in *Mem. Geol. Survey*, vol. iv. p. 350.)

† The rapid changes in the dip of the beds over the ragstone country have been adduced as evidence of great disruption in this district; but these are due to the dissolving of the ragstone and the subsidence of the rocks above. Outside the ragstone country, whether above or below it, the beds are in their usual order, and are comparatively undisturbed. (*See* p. 235.)

We see then, that in the case of the Darent, where no transverse synclinal crosses the Lower Greensand, the escarpment of that formation is *not* breached. In the Stour and Medway valleys, where there is in each case a transverse synclinal crossing the Lower Greensand, the escarpment of that formation *is* breached. Is it not probable that these facts stand to each other as cause and effect?

I have applied the same test to the southern Chalk escarpment, and there the result is very plain. The outcrop of the Upper Greensand between the Arun and the Adur runs in a remarkably straight line, and at each end of the line, at Steyning on the Adur and at Amberley on the Arun, the outcrop descends to the level of the sea, for the rivers at these places are tidal. Now a straight line drawn from Steyning to Amberley passes ⅓ mile south of Chanctonbury Ring, and at this point the top of the Upper Greensand is 250 ft. above the sea. There is therefore a rise of the beds between the rivers; or, what is the same thing, the rivers run in transverse synclinals.*

I should have been glad to have worked this out more thoroughly for other valleys of the Weald, but have not the necessary data at hand. From what materials I have, it seems to hold good there; and I believe, from what I know of transverse valleys, flowing with the dip, in other districts, that it will be found to be frequently the case.

Probably it is owing to these large transverse synclinals that escarpments are breached in so few places by transverse valleys. If it were not for some such cause as this, marking out the lines which the valleys must take, we should expect them to be very numerous. The innumerable streams which would first form on the old plain of marine denudation ought each to find its way *down the greatest slope*, and therefore the escarpment would be breached in a very large number of places. But the transverse synclinals have apparently determined the lines that these valleys must take, and hence they are few in number.

It was stated above that no marked disturbances are known along the Chalk escarpment. There are, however, some faults which are known to enter it, shifting the boundaries at its foot; and some of these seem to have a relation to the more important "*passes*" or deep gaps in the escarpment. It is true that there are several passes, especially in Sussex, which are apparently independent of faults, and there are also faults intersecting the escarpment where there are no passes; but on the north of the Weald there are only three passes of consequence, and these are evidently associated with faults. They are, from east to west:—1st, the broad opening south of Lyminge, which is in fact two passes, divided by Tolsford Hill. Just on the east side of this hill there is a fault bringing the Chalk against the Folkestone Beds, and throwing out from the escarpment the conical hill on which

* This may not seem very clear from the foregoing description, but it will be at once evident by drawing a line on the Map (Sheet 9), in the direction indicated, and comparing that with Hor. Sect., Sheet 75.

Beachborough Summerhouse, is built.* There is another fault a little to the east of this, which throws the Gault, but it is doubtful if it extends to the Chalk. On the west side of Tolsford Hill there seems to be no fault.

2nd. The "pass" at Merstham; here too there is a fault, though not of any great magnitude.

3rd. The "pass" at the western end of the Hogs Back; where there is a fault bringing the Chalk against the Gault. This fault runs N.W. and S.E., whilst the valley in the Chalk runs from S.W. to N.E.; but the point at which the fault crosses the Chalk is that at which the "pass" occurs.

There is a well-marked fault north of Betchworth, and two others near Wotton and Albury (all in Sheet 8); but these, though throwing the Upper Greensand boundary, are not associated with passes.† On the other hand there is a pass just to the west of Farnham, where there is no evidence of a fault.

There are several passes in the South Downs; but, with one exception, they are not known to be associated with faults. The exception is that on the west of Piecomb, where the Greenhurst anticlinal enters the Chalk country. There is also an east and west fault here.

Now it is important to remark that these passes have no relation to the drainage of the country inside the Chalk escarpment. Some of them open into valleys which carry streams, others into "Nailbourn" valleys, with only occasional streams after wet seasons; but all the water which these valleys carry away *falls upon the Chalk*; in no case does any stream run outwards from the Weald through them.

There is a third kind of valley interrupting escarpments, through which the stream flows inwards, or towards the central country. A good example is the Plaxtole Brook, near Ightham, which rises at the foot of the Chalk and runs *against the general dip* southwards to the Weald Clay. I think that such valleys are likely to coincide with local transverse anticlinals, or—which is the truer way of expressing it—that a transverse anticlinal will probably give rise to such a valley.‡

If we imagine a "plain of marine denudation" sloping northwards, with the northerly dip of the beds in excess of the slope of the ground, then weathering will in time produce a ridge or escarpment of the harder beds (say of the Lower Greensand) running east and west. But if there be a transverse anticlinal crossing this plain, the underlying softer bed (the Weald Clay) will stretch in a curved line further down the slope to the north, the escarpment will necessarily curve round this line. The result of this will be that springs round this curve will flow southwards

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* *See* frontispiece; the hill is seen from the east, the fault is on the west side of the hill.

† It should be noticed that these faults intersect the escarpment very obliquely.

‡ Mr. Martin has somewhere stated that the Plaxtole Valley *is* transversely anticlinal; but he is not a trustworthy witness on this subject, constantly mistaking local slips for true dips:—such are his "lacerated escarpments," &c.

into the main longitudinal valley of the Weald Clay, and hence, in consequence of this transverse anticlinal, there will in time be a brook flowing from north to south, or against the general dip.

The results then at which we arrive are these:—

1st. *Transverse valleys,* running *with the general dip,* and draining the longitudinal valleys, lie in large* *transverse synclinals.*

2nd. *Transverse valleys,* running *against the general dip,* and running into longitudinal valleys, lie in local *transverse anticlinals.*

3rd. *Passes* are apt to occur where escarpments are faulted. The pass is at the head of a valley which runs from the escarpment in the direction of the general dip, and has no effect upon the internal drainage.

The general mode of breaching escarpments is for the main rivers to flow through them *with the dip,* that is *from* the plain facing the line of cliff. But this plain, if escarpments are old sea-cliffs, represents the old sea-bed. Therefore in nearly every case in which sea-cliffs, by a rise in the land, become inland escarpments, there is also a *reversal* of *drainage.*

Probably no one would admit even the probability of this. Yet it is absolutely certain that if escarpments are old sea-cliffs such reversals have taken place. Equally certain is it that if our present sea-cliffs are ever, even in one respect, to resemble escarpments, such reversals must take place.

Mr. Searles Wood, junior, contends that in the north-eastern part of the Weald there has been a reversal of drainage; that the sea once flowed through the transverse valleys, and that afterwards, by the continued uprising of the land, these gorges became river valleys, draining southwards; the reversal which caused the streams to run in their present direction being of comparatively recent date. One argument relied on to prove this is the distribution and composition of the gravels within and without the Weald; this we will consider presently. Another argument is the "trumpet-shaped mouths" of the transverse valleys which open into the Weald on the north, whilst "the gorges of the South Downs present no such feature." It is stated that such trumpet-shaped openings are the wide mouths of the valleys which drained from the north into the Weald.†

It is rather singular that Mr. D. Mackintosh has used this argument (not with any reference to the Weald) in an opposite sense.‡ He states, as one objection to the subaërial theory, that:—"It offers no explanation of the important fact that many of the transverse gorges leading out of, or into longitudinal valleys have a *fresh aspect* and commence abruptly. The brinks of their precipitous sides are generally sharply defined, and they open suddenly and unexpectedly on the sides of the longitudinal valleys,

* By this is meant an anticlinal affecting a large or wide area, not necessarily large in amount; for the cross dip due to these anticlinals is evidently very small.

† *Quart. Journ. Geol. Soc.,* vol. xxvii. pp. 13, 15, 20.

‡ *The Scenery of England and Wales,* p. 243.

instead of the longitudinal valleys graduating into them, in trumpet-mouth-shaped fashion, as would be the case had rains and rivers simultaneously excavated both."

The first-named author regards the presence of "trumpet-shaped mouths" to transverse valleys as evidence against their excavation by rivers flowing in their present direction; whilst MR. MACKINTOSH considers that such valleys should have trumpet-shaped mouths, whereas generally they have them not. Probably the exact shape of the "mouth" has nothing to do with its origin, but depends upon the structure of the rock, and perhaps too upon the dip. The widest "trumpet-shaped mouth" is that of the Stour, where it breaches the Chalk escarpment; going westward they diminish in size, whilst on the south of the Weald they are absent. Now in Kent the Chalk is soft and has not been much used, so far as I know, for external work in building; but in Surrey and Sussex it has frequently been so employed.

The transverse Chalk valleys of the South Downs have their sides much steeper than have those which intersect the North Downs. This is especially the case with the Arun and Adur; and these are the valleys whose openings to the longitudinal valley of the Gault are most abrupt. These appearances indicate a greater hardness in the rock.

It seems too that "trumpet-shaped mouths" are likely to occur where the dip is small, and that the "mouth" will be abrupt where the dip is high; but this is a point which requires investigation.

The fact that the escarpments of the Weald, and those of every other part of the world, run *along the general strike*, is well enough known.*

As the ground rises towards the watershed, of course the escarpment does not run along the *actual strike*, but the obliquity is so small that the dips taken along the outcrop are nearly always apparently at right angles to the escarpment. The important point, however, is this, that the face of the escarpment exhibits everywhere along its course and at its foot the same set of beds, whilst sea-cliffs intersect different beds in different places. In fact, atmospheric action makes escarpments; the sea cuts sections.†

In the various sections illustrating this memoir it will be seen that the highest ground is always at, or very near to, the crest of the escarpment, and that the ground falls very gradually down the dip-slope.‡ Not only is this so in the Weald, but it is the case with every line of escarpment; the exceptions, if any, being of the very rarest occurrence. There may be apparent exceptions to this rule, as when another hard bed comes on very soon; but this forms another escarpment. This is the most remarkable fact with regard to escarpments, and it is that in which they most

* This important fact was, I believe, first fully stated by the REV. O. FISHER. *Quart. Journ. Geol. Soc.*, vol. xviii. p. 3.

† *See*, for a comparison of the escarpments and Sea Cliffs of Yorkshire, *Geol. Mag.*, vol. iii. p. 435.

‡ See especially those in Chap. xiv., p. 226 *et seq.*

strongly differ from sea-cliffs. There may possibly occur cases where the base of an escarpment keeps comparatively level for some distance; there may perhaps occasionally be accumulations at its foot which it is impossible to prove are not marine;* but nowhere does the summit of a line of sea-cliffs form, all along its course, the highest ground of the country.

PROF. RAMSAY has shown that the foot of an escarpment is at different levels at different parts of its course.† Not only is this so, but the bases of different and parallel escarpments are at different levels on the same meridian;—that is, the rise and fall of parallel escarpments along equal lines are not equal.‡

If escarpments are old sea-cliffs, each escarpment must once have been at the same level all along its course; and if we had only one line of escarpment to deal with it might be said that the present inequality of level is owing to unequal upheaval of the land, subsequent to its formation by the sea. But in the case of parallel lines of escarpments, the bases of which are at different heights on the same meridian, it is requisite to assume special inequalities of upheaval, *since the denudation of the district*, along each line of escarpment; a supposition so improbable that probably no one would maintain it.

If, however, escarpments are due to weathering, the material worn away by the weather being carried away by the streams, the reason for their varying heights is plain enough—the bases of the escarpments *rise towards the watersheds.*

If, as has been suggested above, the transverse valleys lie in large synclinals, then the areas between them lie in large transverse anticlinals, and *a part* of the rise towards the watersheds may be due to this cause.

Another great difficulty in regarding lines of parallel escarpments as old sea-cliffs is this:—that the sea would only occupy long and narrow strips of country in which the waves would have little or no power.§ In this view of the case those who advocate *tidal erosion*—by the full force of an assumed tidal wave, rushing up the Channel and scouring round the Weald—have an advantage over the advocates of ordinary marine action.‖ The general arguments against tidal denudation are, however, even stronger than those against ordinary marine action. It is assumed that only the North Downs stretched across the Channel, and that the tidal wave, striking against this old isthmus, was deflected round the

* There are no such deposits in the Weald.

† *Loc. cit.*, p. 77.

‡ *See* the sections in Chap. xiv. It should be remembered that there are several escarpments in the Weald. There are, almost universally, those of the Chalk and Hythe Beds. Through W. Surrey, Hants, and the greater part of Sussex there is the Upper Greensand escarpment. In W. Sussex the Folkestone Beds make an extremely well-marked escarpment; so that here there are *four* parallel lines; and if we take the line of Chalk hills described on p. 267 as an old escarpment there are five (*see* fig. 42, p. 226). Besides this, where the Greenhurst anticlinal passes, the escarpments of the Folkestone Beds and Hythe Beds are twice repeated.

§ PROF. RAMSAY, *loc. cit.*, p. 79.

‖ MR. S. J. MACKIE and MR. S. V. WOOD, JUNR. *See* the references to their papers on p. 25.

Weald. It has been already shown that the South Downs are as likely as the North Downs to have joined the Chalk of France, and if this were so, the "tidal wave" could not get into the Weald, nor could the sea-water itself do so, excepting through the narrow transverse valleys. Supposing, however, that only the Straits of Dover were closed, and that the tidal wave rushed up the Channel, with increasing force in consequence of the lessening area, it would surely *lose its force* when it entered the Weald; for only part of it could come on the English side, the other part would be wanted to denude the Lower Boulonnais. Again, the Weald Clay, near the borders of Romney Marsh, is at a considerable height above the sea, from 100 to 200 feet. If the country were depressed to allow the sea to flow over this part, the Weald Clay near the Medway would be from 100 to 150 feet below tide mark; other parts would also be much below water, and some would be far above it; in fact the difficulty of unequal level is as much opposed to tidal denudation as it is to ordinary marine action.

But supposing all these difficulties smoothed over,—the Weald Clay, the Gault, and other longitudinal valleys adjusted to one uniform level, the Straits of Dover closed, and a huge tidal wave rolling up the Channel; is there any evidence that such a wave would have even the slightest effect in denuding the land? There is none whatever.

It is the breakers that wear back the cliff: or rather it is the breakers that pound up and carry away what the weather throws down from the cliff. Tidal currents run strongest where the breakers have least power, and here "marine denudation" is at its *minimum*.

Tidal currents run strongest through groups of islands, or between small islands and the main land; as on the west and north of Scotland, and off the coast of Norway. But these areas are known to be submerged land surfaces; the fjords are submerged land valleys, and the islands are the tops of submerged hills. The waves of the Atlantic are slowly doing their work in denuding the exposed faces of these islands, but the tidal currents run along the shores and often leave even the glacial striæ for a long time uneffaced.

Glacial action has been invoked to account for the denudation of the Weald, and especially to explain the origin of escarpments.* Now, of this theory it can only be said that we have little or no knowledge of what action moving ice has on alternations of soft and hard rocks. We can study the sea, the tidal currents, and the weather, where they are actually at work; but we cannot get beneath the great ice-sheet of Greenland to study that. That glaciers can and do deepen valleys is well known; that a glacier can of itself originate a valley is doubtful. But if this be allowed, there is no evidence that a moving sheet

* *See* Rev. O. Fisher. *Geol. Mag.*, vol. iii. p. 483, 1866.

of ice could denude a long valley, such as those of the Weald Clay and Gault; leaving long lines of projecting rock *along the strike.* Glaciers do make hollows in the softer rocks, and these hollows remain as lakes when the glaciers disappear. In the north of England, which is known to have been planed down by moving ice, such small lakes exist, or have existed, in abundance; but is there one within the Weald?* My experience in the north of England teaches me that glaciers have masked and destroyed escarpments, but have not made them.

The most important objections to this glacial theory, however, are these:—1st, that it offers no explanation of the transverse river-valleys; 2nd, that whilst the assumed *cause* has been in action in the low lands only over the northern half of the temperate zone, the *effect* is of universal occurrence. Escarpments are found in every part of the world, and everywhere they have the same general characters as have those with which we are now more particularly concerned; generally too such escarpments, at some part of their course, are breached by transverse river-valleys *running with the dip.*

Although we cannot admit that glacial action has eroded the Wealden valleys, or formed the escarpments, yet the influence of the glacial period must have been great during a part of the denudation. Subaërial action must then have gone on at a vastly greater rate, and the rivers must have run in enormously greater volume than now. Probably it is to this period that we must refer the great deposits of brickearth in the Maidstone district, and over the Weald Clay, near Hadlow. We can hardly conceive that the present rivers, under our present climate, or under any at all resembling it, could form great spreads of finely-laminated loam, 50 feet or more in thickness. Nor does it seem likely that the weathering action now going on will form such subaërial deposits as that of the chalky wash near Aylesford, the "head" which overlies the raised beach of Brighton, or that which covers the old beach at Sangatte. Such deposits MR. GODWIN-AUSTEN long ago termed "Subaërial Beds."† MR. A. TYLOR has more recently employed the term "Pluvial Period,"‡ to the time during which the great gravel and loam deposits of our rivers were formed.

Probably both the true subaërial deposits, and the great river-gravels and loams, are referable to the "glacial period" of the south of England.

I shall not in this Memoir attempt to correlate the gravels of the Weald with those of other districts, whether these latter be of river origin or not. To do this would involve a long discussion, and a review of the phenomenon over an extensive area. But this is not at all necessary to our subject; it will be sufficient to

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* Lest anyone personally unacquainted with the Weald, and studying its features only with the aid of the Ordnance Maps, should suppose that the sheets of water scattered over the country are *lakes*, I may here mention that they are all artificial ponds, mostly belonging to the old ironworks. (*See* Chap. xix.)

† *Quart. Journ. Geol. Soc.*, vol. vii. p. 118, 1851.

‡ *Ibid.*, vol. xxiv. p. 103, vol. xxv. p. 57.

show that the gravels and loams now found within the Weald are of river origin, and are due to rivers flowing in their present direction.

There is, as yet, no proof that the Wealden area participated in any of the movements of land which occurred north of the Thames during the glacial period. It might have been raised to a great height above the sea; but in this case we should have no record of the fact, save in the greater subaërial action which this would produce.* But we have no means of distinguishing the effects due to this cause, from those which would result from a change of climate with the land remaining stationary. If, however, the area had been depressed beneath the sea we should somewhere have evidence of it; in raised beaches, marine silt, or some other form; but there is none. All the superficial deposits within the Weald are such as, in other districts, Geologists now generally agree in considering as river-gravels and loams. They can all be fully accounted for in this manner; and they can also be shown to be the product of river action, by rivers flowing in their present direction.† The greater part, I think, can fairly be accounted for in no other way. We are then justified in believing that before, during, and since the "glacial period," denudation from subaërial causes has been uninterruptedly going on in the Wealden area.‡

That the Thames Valley should serve as an axis of movement is of itself a remarkable fact, and such a statement might fairly be received with distrust. But when we consider that the Thames Valley roughly coincides with an old ridge of Palæozoic rocks, and remember further that both in the original upheaval of the Wealden area as a whole, and in the minor foldings which accompanied this, the lines of movement took an east and west direction opposed to the lines of upheaval in other parts of England, but *all more or less parallel to this old ridge*, and to the old folds of the Palæozoic rocks, there is nothing remarkable in later and far less important movements taking a similar course.

But there is one fact, not I think noticed as yet, which renders it to some extent unlikely that the east of England has undergone very unequal movements in recent geological times. If we draw a line from the south-eastern end of the Eastern Moorlands of Yorkshire, past the southern end of the Pennine Chain, the Malvern Hills, and the Quantocks, to the south-eastern corner of Dartmoor, we shall find that all the summits to the south-east of that line, with very few exceptions, are below 1,000 feet. The only exceptions are both on the Cotteswolds (the Inferior Oolite

* "The only physical condition which I can imagine sufficient to account for the fragmentary detritus generally of the whole of those areas from which I have borrowed illustrations, is that of an elevation of great amount, such as would place the whole of the higher portions of this country in regions of excessive cold."—GODWIN-AUSTEN, *loc. cit.*, p. 130. (*See* also *Trans. Geol. Soc. Ser.* 2, vol. vi., p. 437.)

† Possibly with a few exceptions hereafter noted, *see* p. 297.

‡ MR. S. V. WOOD, JUN., believes that during the formation of the Boulder Clay of central England, the Weald was covered by the sea. *Quart. Journ. Geol. Soc.*, vol. xxvii. p. 7.

escarpment) north-east of Cheltenham; they are Cleeve Cloud 1,080 feet, and Broadway Hill 1032.*

The summits of the various hills and escarpments rise to heights of 700, 800, and in a very few cases to 900 feet. They evidently point to the former existence of a great plain of marine denudation over this area. This plain is far older than the Glacial period; for the escarpments, around which the Boulder Clay and other accumulations of that period have accumulated, have been carved out of it. It is later than the Eocene period; for outliers of that formation lie scattered over the plateaus, far up towards, and often upon, the escarpments.

If the south of England had remained practically stationary, whilst the area further north had been greatly depressed, it is certainly remarkable that on the re-elevation of the country the summits should obtain such a striking uniformity.

It would seem, from the supposed westerly extension of the Brighton raised beach, that, at some time, the western end of the Weald has undergone a slightly greater upheaval than the eastern part. The old beach at Kemp Town on the east of Brighton is from 8 to 12 feet above the present beach; but going westward it rises, until it attains a height of 140 feet at Bourne Common, 38 miles from Kemp Town. Beyond this it appears to fall, for at the western end of the Portsdown Hills it is between 100 and 125 feet.† So that the total difference in elevation is about 130 feet, in 38 miles.

This unequal height of the old beach is a point of some importance in the question of Wealden denudation. A subsidence of 140 feet would submerge a considerable part of the western part of the Weald. It would convert the transverse Chalk and Lower Greensand valleys of the Adur and Arun into sea inlets, with nearly 24 fathoms of water; and it would lay a large area of the Weald Clay under the sea.

Now it may be assumed that when this old beach stood at the sea-level, the land was thus submerged; but this is altogether an unwarranted assumption. It is far more likely that the main rivers in the west of the Weald have cut their valleys 140 feet deeper since that time. If not, why do we not find marine deposits somewhere up those valleys in the Weald, or scattered over the *dip-slope* of the Lower Greensand?

Again, it may be thought that such an unequal elevation would throw the internal drainage of the country into confusion. But this would not be the case. A rise of 130 feet in 38 miles is at the rate of 3 feet 4 in. per mile. Now such a rise as this, even if it took place suddenly, would have no important effect on the general drainage. It is only on the sluggish streams of the Weald Clay that it would be seriously felt; and even here it would only

* Inkpen Beacon, the summit of the Chalk, was formerly considered to be over 1,000 feet; it is only 972 above mean sea level.

† *See* Mr. Prestwich's papers. *Quart. Journ. Geol. Soc.*, vols. xv. p. 215, xxviii. p. 38; and Mr. Codrington's paper, *Ibid.* vol. xxvi. pp. 534, 543, 547.

somewhat impede the drainage, not reverse it.* Moreover, its influence would only be felt on those streams which flow east and west; those which flow approximately north and south would be quite unaffected.

But it is highly improbable that such a change took place suddenly; and if slowly, the streams would easily adjust themselves to the altered slope.

We will now review the facts stated in Chapter XII., wherein the river-gravels are described; and see what evidence is there afforded as to the Denudation of the Weald.

The first point to remark is the small area over which the gravels extend in the central districts. In the Hastings Beds area it is only along the borders of the present streams that any gravels occur: they do not occupy any great extent of ground, nor do they rise to any noteworthy height. I believe that there is no spot within the Hastings Beds where river-gravel is found at a greater distance than a mile from the present streams; nor do they anywhere rise to a greater height than 40 or 50 feet above those streams. Therefore the amount of river erosion, which can actually be proved for this central district, is small.

But although only a small amount of subaërial denudation can thus actually be here proved; yet the absence of any drift whatever over the greater part of the area is in itself good evidence in favour of subaërial denudation. Any agent of denudation, other than rain and rivers, must have left its mark on the country. Marine denudation must somewhere have left beaches; tidal erosion must, in some one or more of the many sheltered spots, have deposited drifted materials; glaciers must have left moraines.

If it be contended that such evidences may have been there, but that subsequent subaërial agencies have destroyed or obliterated them, then this admission virtually concedes the point in dispute; for a denuding agent that could do thus much, could, in longer time, do much more.

Again, if subaërial action has been limited to destroying the evidences of other denuding agents, then the gravels which fringe the present streams should be composed partly, if not mainly, of the products of these denuding agents. They should contain in abundance such materials as we now find in sea-beaches along the south-eastern coast; above all they should be plentifully supplied with flints; but this is not the case. The pebbles in the gravels over the central area are *strictly local.* In only two instances, so far as I know, have flints been found; these were both near the border of the Hastings Beds.

When we remember that the Chalk once stretched over the entire district, and that it has been removed from the central country by marine denudation, we might reasonably expect to

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* The River Medway between Leigh and Yalding, the *flattest* part of its course, falls 40 feet in 9 miles, or at the rate of nearly 4½ feet per mile.

find here and there, near the border, a few flints remaining on the surface. The occurrence then of an occasional flint in the gravel should not surprise us; rather should we be surprised at their being so rare, that weeks of careful searching have failed to find them in all but two places.*

Although, where river-deposits occur far above the present streams, we have good evidence of river denudation; yet the absence of such deposits is no proof, nor even presumptive evidence, that such river denudation has not occurred. For as soon as a river lowers its bed, and leaves a gravel terrace as evidence of its former level, this terrace is attacked by subaërial agencies, and must in time succumb to them.†

Lastly, upon this part of our subject we may remark that such evidence of river erosion as we now find in the central country, can be explained only by the agency of rivers flowing in their present courses.

When we pass to the Weald Clay country we find the problem apparently much less simple. If we follow the River Teise‡ downward past Lamberhurst, we find the gravel such as we have just described, wholly composed of Wealden pebbles. On reaching the Weald Clay flat the gravels are still the same, but they spread over a wider area, and attain a somewhat greater height above the stream. The Teise divides into two portions, and the eastern branch falls into the Beult. Just hereabouts we find occasionally, though very rarely, a stray flint or Tertiary pebble. But from Hersfield Bridges eastwards, all along the Beult, the gravels contain Wealden pebbles only. The very few foreign pebbles which these gravels contain on the west may possibly have drifted along from the western branch of the river, when the old wide alluvial plain was in flood;§ or they may be simply the remains of the higher Cretaceous and Tertiary beds which once stretched across here. The nearer we get to the Chalk escarpment the greater the likelihood of finding such remains.

The fact that, with a very few exceptions near this western end, the gravels of the Beult and Teise are entirely made up of Wealden pebbles, can only be explained by supposing them to have been wholly deposited by those rivers when flowing in their present courses; for the streams which feed those rivers rise wholly within the Weald Clay and Hastings Beds, and can only bring down such material as those beds contain.‖

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* *See* pp. 186, 187.

† See the remarks, quoted from PLAYFAIR, at the end of this chapter.

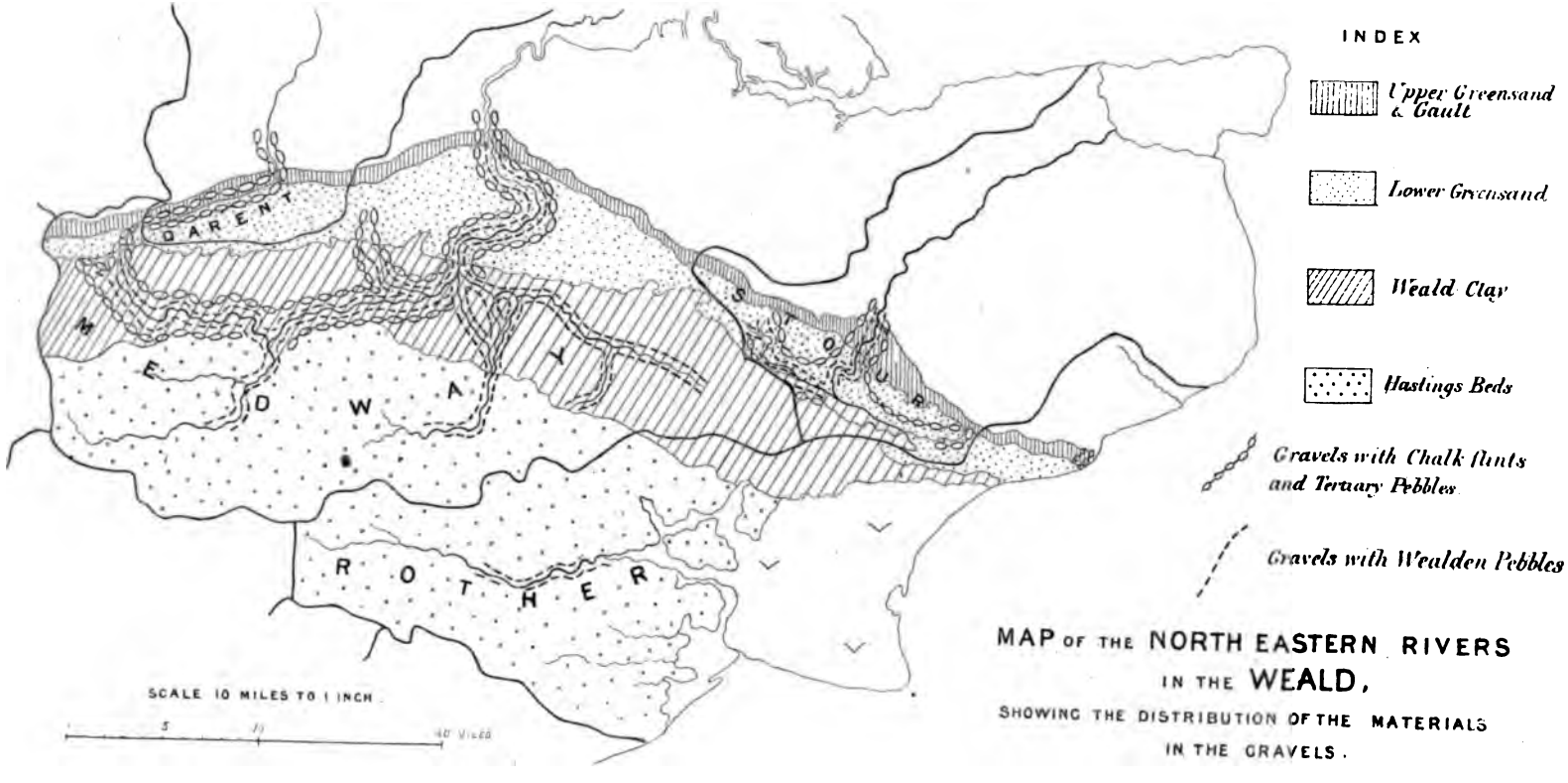
‡ One of the eastern tributaries of the Medway.

§ Perhaps carried along by ice, driven by the south-westerly winds.

‖ It may be objected that the Beult at least should contain fragments of Lower Greensand, since a few of its tributary streams rise at the foot of the escarpment of that formation. But the Hythe Beds on the east of the Medway consist almost wholly of "Hassock" and Kentish Rag. The former cannot form gravel, but wears at once into sand; the latter, even if it gets into the gravel, will soon be dissolved, for it is as soluble as Chalk in carbonated water. Ragstone is not abundant in gravel, even over the Lower Greensand area; though in a few cases both it and Chalk have been preserved

PLATE VII.

To face P 289.



MAP OF THE NORTH EASTERN RIVERS IN THE WEALD, SHOWING THE DISTRIBUTION OF THE MATERIALS IN THE GRAVELS.

If we pass to the River Medway itself, which receives its eastern tributaries at Yalding, we find a very different state of things. The gravels of the Weald Clay in this district everywhere contain flints and Tertiary pebbles in abundance; and with this we note the fact that the river is supplied by tributaries which flow down through the Lower Greensand from the Chalk escarpment. On the edge of the Chalk escarpment, near Godstone, there are patches of Tertiary pebble-beds; and others no doubt occurred further to the south, which have been worn away by the recession of the Chalk escarpment. There is also on the watershed of the Medway and Darent, at Limpsfield Common, a large patch of gravel composed of flints and Tertiary pebbles. The origin of this is somewhat doubtful, and to this subject we will return immediately, but at present we will only note it (and probably others like it, now destroyed) as one source of the flints and Tertiary pebbles which abound in the gravels of the Eden.*

The higher branches of the Medway itself rise in the Hastings Beds country. The gravels of this part contain Wealden pebbles only, and it is not until we reach Penshurst, where the Eden falls into the Medway, that flints and Tertiary pebbles occur.† There is a tributary of the Medway which flows down from the Chalk, past Plaxtole, and joins the main river below Hadlow. On the right bank of this brook, at Dunks Green, there appears to be preserved in a patch of gravel the old gravel of this brook (now about 60 ft. above it), which brought down flints and chalk from the north; and in the same patch, on its southern face, there is the old gravel of the Medway, which then, as now, carried flints and *Wealden pebbles*.

The evidence then of the gravels of the western part of the Medway is as conclusive as that derived from the eastern half; and it proves that the gravels were made by the rivers when flowing in their present direction.

The distribution of these gravels is entirely opposed to any theory which would attribute the excavation of the Weald Clay plain to any large river or current of water running *along the whole* plain from west to east, or from east to west. For in that case the gravels of the eastern and western branches of the river should be alike, whereas they widely differ. But the differences they exhibit are just those which they necessarily would possess if they were due to river action, and to river action only.

The gravels on the Weald Clay north of Tunbridge are important for the height to which they extend above the river. Though much less than those of the Lower Greensand, they are far higher than any on the Hastings Beds. The river at Tunbridge is about 50 ft. above the sea; at Yalding it is about 20 ft. The highest patch of true river gravel is perhaps that north of Starve Crow, which is 200 ft. above the river. Since the River Medway deposited this gravel it has eroded its valley to a depth of 200 ft. and a width of four or five miles.

* The westerly tributary of the Medway.
† Save in the one instance noted on p. 186.

The small patch of gravel at Little Park, just to the north of that last mentioned, is equally interesting. It consists of angular fragments of chert, wholly unlike a river gravel, and can only be regarded as a relic of the Lower Greensand escarpment, or as a subaërial wash from that escarpment, when it reached a mile and a quarter further south than it does now. This is 20 ft. higher than the patch of river gravel, and probably gives us the position of the escarpment when the river ran at its high level.

The gravels overlying the Weald Clay in the other river valleys are of less importance than those of the Medway in proving the *amount* of river denudation; but there are one or two points of interest which may here be noticed.

In describing the gravels of the Arun it was shown that in the higher parts of the valley, near the Lower Greensand of Surrey, there are numerous patches of angular chert capping the hills, just as we have already seen to be the case with the Medway valley near the Lower Greensand of West Kent; but in the latter locality the deposits are less numerous. These deposits in the Arun valley *contain no flints*, and they occur opposite those parts of the escarpment where the Hythe Beds contain Chert. They are evidently either the actual remains of the Lower Greensand escarpment or a wash from that escarpment when it reached further south than now.

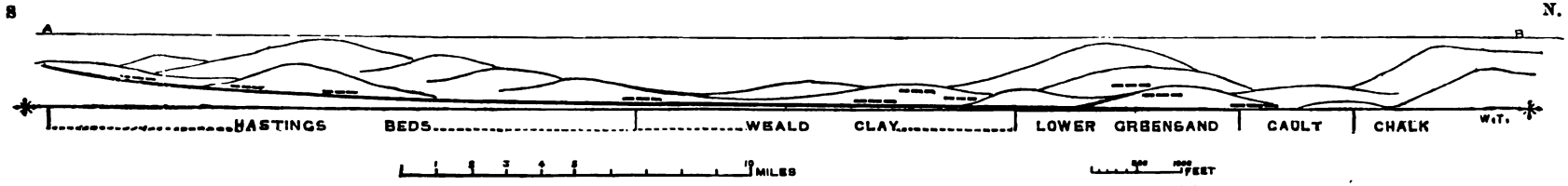
The same thing occurs in the western part of the Mole Valley, near the watershed, in the immediate neighbourhood of Leith Hill. In the Wey Valley, where the river gravels are well developed, the true subaërial beds have been destroyed and their material are now found in the river gravels. So far as I know flints do not occur in the Weald Clay gravels of the Wey.

The Lower Greensand escarpment from Leith Hill to Hindhead, which forms the northern boundary of the Arun Valley, is very lofty, and the beds here are thick; the Chalk which occurs to the north of it has a high dip. The old plain of marine denudation would then evidently have entirely removed the Chalk from the southern part of the Lower Greensand; hence the reason for finding no flints on the Weald Clay there. But in the case of the Mole Valley the Lower Greensand is somewhat thinner, its escarpment is less lofty and the dip of the Chalk is less.* The Chalk would therefore extend further south over the old marine plain here; and here, in the northern part of the Weald Clay area we find flints. These flints may be the remains of the Chalk which once stretched over here, or they may have been brought down by the stream which rises at Merstham and flows past Redhill to the Weald Clay. Either of these explanations accords well with the subaërial theory of denudation; but the distribution of the gravels in the three rivers here described (equally with

* Compare the sections on pp. 230 and 231. which extend to the Weald Clay of the Wey and Arun Valleys, with that on p. 233, which shows the Weald Clay of the Mole Valley.

Fig. 59. Diagram of the Course of the River Medway;

Showing the fall of the Stream, the height of the Old River Gravels, and the summits of the Watersheds.



Approximate scale for length. Scale of heights

** Sea level. - - - Heights attained by the Old River Gravels.

The curved thick line shows the fall of the River Medway.

A B. The old Plain of Marine Denudation.

the gravels of the Medway) is entirely opposed to any other theory which has yet been advanced. Indeed the facts can only be explained by subaërial action, and the agency of rivers flowing in their present directions.

In East Sussex, where the Lower Greensand is thin and does not form an escarpment, Chalk flints are found over the Weald Clay; the Chalk of the old marine plain no doubt extended well over the Weald Clay here. The gravels of this district consequently contain flints; but those of the higher branches of the Ouse, in the Hastings Beds, contain Wealden pebbles only.

The gravels of the Adur, over the Weald Clay flat, also contain some flints and Tertiary pebbles. Perhaps these also were left by the marine plain; but the Lower Greensand escarpment is higher here, and the beds composing it are thicker, therefore the Chalk would not have extended so far over the Weald as it did further to the east. In West Sussex the Lower Greensand, even at its highest points, is frequently covered with a thin coating of angular flints.* Possibly these may be the remains of the Chalk of the marine plain, or they may be a part of the great Hampshire sheet of gravels which extends over much of the high lands of that county. † The deposition of this Hampshire gravel, whatever its origin, has certainly preceded the excavation of the valleys; and some of it may have extended over the old marine plain of the Weald; and then have been let down, on to the Lower Greensand, when the Gault and Lower Chalk were removed by subaërial action.

Whatever this angular gravel on the Lower Greensand may be, it is certainly not the product of ordinary marine denudation, nor could it have been brought there by tidal currents. It is too angular for river-gravel, and it is utterly unlike anything that we know to be of marine origin.‡

We return now to the northern side of the Weald, and will consider the gravels overlying the Lower Greensand of that district. Of these the most important, as proving the amount of river denudation, are those of the Medway; but in other respects the evidence afforded by the gravels of the Darent and the Stour is equally valuable.

All the tributaries of the Medway unite at Yalding into one stream, which then flows through the Lower Greensand escarpment. We have seen that these tributary streams bring down different material, according to the rocks they traverse; but from Yalding downwards through the Lower Greensand country there is but one stream, which of course carries along the collected

* See Sir R. Murchison's Paper. *Quart. Journ. Geol. Soc.*, vol. vii. p. 351, and figs. 2 and 3 of that paper. The thickness of the "flint-drift" is enormously exaggerated in these drawings.

† See Mr. Codrington's Paper. *Quart. Journ. Geol. Soc.*, vol. xxvi. p. 528.

‡ I speak here of the flints on the Lower Greensand, not of the Hampshire gravel beds themselves; although the flints of these are far less rounded than are those of modern shingle beaches.

gravels of its tributaries.* Consequently, there is no place along the river where the gravels are wholly composed of one set of materials; and, if the higher gravels over the Lower Greensand country have been formed by the Medway, flowing in its present direction, they too should everywhere present a similar mixture of materials. This is everywhere the case.

The strongest evidence in favour of this, is the immense quantity of Wealden pebbles which the gravels contain, particularly those of the higher levels.† It is impossible to conceive that any marine current, or river flowing from the north, could have formed this gravel, which sometimes contains half its bulk of Wealden pebbles. In the lower gravels Wealden pebbles are less common, and in some places one has to search the gravel-pit for some time before finding one (*see* p. 174). Yet these are the gravels that all but a few geologists would now admit to have been formed by the Medway, when flowing in its present direction.‡

The fact that the low-level gravels about Leybourn and Aylesford contain so few Wealden pebbles, whilst the gravels of the higher levels contain so many, is easily explained. The Wealden sandstones are soft, and wear down readily into gravel; mere rain-ruts by the road-sides in the Weald often contain well-formed pebbles. Sandstone that goes so easily into gravel does not require a great deal of wear to grind it into sand. As the gravel travels slowly along the river-bed the materials are exposed to long-continued wear and the softer parts are liable to be destroyed. We have every reason to believe that the ancient rivers of the Weald, those which formed the high-level gravels, and which spread out the great deposits of brickearth, ran in much greater volume than the modern rivers do. They would therefore quickly bring down material from the central country, and the soft Wealden sandstones would have a greater chance of being preserved.

But it by no means follows from this that the high-level gravels far down the Medway Valley, and those of the Thames, into which the Medway flows, should contain Wealden pebbles. For the greater the distance which these pebbles had to travel, the less the chance of their being preserved *as pebbles*. The Wealden pebbles over the Lower Greensand are generally very small, and a little additional wear would have destroyed them. The Wealden sandstones have, no doubt, been carried into the Thames Valley; but it must have been in the form of sand and loam; not as pebbles.

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* There are small tributaries flowing into it. One of these, coming down from the Chalk near Boxley, has brought fragments of that substance into the low-level gravels of the Medway.

† Pebbles of Wealden sandstone, whether derived from the sandstone beds of the Weald Clay or from the Hastings Beds, may always be distinguished by their extreme fineness of grain, and by their thinness. They are generally so thin in proportion to their length and breadth as to be easily broken by the fingers.

‡ They are thus shown by Mr. Searles Wood, junr., in his map in *Quart. Journ. Geol. Soc.*, vol. xxvii., Pl. I.

It is necessary to discuss this question in some detail, as the reputed absence of Wealden pebbles from the gravels of East Essex and the Canterbury heights has been regarded as a conclusive argument against the Medway, and other Wealden rivers, having flowed in their present direction at the time when these gravels were deposited. MR. SEARLES WOOD, JUN., relies chiefly, though not entirely, on this argument in his endeavour to prove that the higher gravels of the Medway are *marine*, and were transported through the Chalk valleys from the north; notwithstanding the fact that these high gravels are especially characterised by the presence of an abundance of small Wealden pebbles, which beyond all doubt were brought from the south.* But this argument is founded upon a misapprehension of the character of the Wealden rocks. It is stated that "the Hastings-Sand formation abounds with indestructible gravel-forming material, and in as large a ratio at least as does the Chalk."† To get an idea of the relative destructibility of Chalk-flints and Wealden sandstone one should examine the shingle at the foot of a Wealden cliff. The shingle of the south-eastern coast travels from west to east; therefore the flints in that on the east of Hastings have come from Beachy Head, or from the Chalk further west; and in doing so they have passed along eight miles of Wealden coast. The cliffs both on the west and east of Hastings are constantly falling, and throwing large quantities of stone on the beach; yet it is by no means an easy task to find a pebble of Wealden sandstone amongst the shingle. We rarely do so amongst the larger pebbles; but on scraping these away, and searching underneath, we may get a few small flat fragments of Wealden ironstone and sandstone. No doubt some of the hard calcareous grit (Tilgate Stone) which occurs in the Cliff, goes for a time into the shingle; but from its calcareous nature it would not be long preserved. There is not much of this in that part of the Hastings Beds area which drains into the Medway; and should any get into the gravels, it could not always be distinguished from Kentish Rag.

The Lower Greensand gravels of the Medway extend to the height of rather more than 300 feet above the river. The highest patch, that on the east of East Malling Heath, is of small extent, and not much of it is seen; but there are large pits of brickearth close by, and this differs in no respect from that found at a lower level near Maidstone. The gravel near Barming Heath is, at its highest point, nearly 250 feet above the river; that near Pennenden Heath, on the right bank of the Medway, about 200 feet. That on the north of East Malling Woods extends upwards to 150 feet

* The presence in the gravels outside the Weald of a few fragments from rocks below the Chalk, MR. SEARLES WOOD explains by assuming a "tidal flow up the inlets," in which he regards these gravels as having been deposited (p. 9). But no explanation is given of the enormous amount of Wealden material in the gravel overlying the Lower Greensand; surely something more than a "tidal flow" is required to account for this.

† *Ibid.*, p. 8.

above the river. From this level there are gravels at all heights down to that in the bed of the present river. These gravels all have the same general composition. If they differ at all, it is in the larger quantity of Wealden pebbles which the higher gravels contain. That is to say, the proof of fluviatile erosion by a river running from south to north, or in the present direction of the Medway, is stronger in the higher gravels than in the lower.

The gravels of the Darent are not remarkable for the height to which they rise above the river, although they are sufficient to prove a denudation of more than 150 feet. But they are important for this; that they, alone of the gravels of Wealden rivers, nowhere contain a trace of material from the Weald Clay or Hastings Beds. But the Darent, alone amongst Wealden rivers, has no tributary flowing from the Hastings Beds or Weald Clay. I mapped the gravels of this river with great care, and examined every section of gravel exposed—some of them repeatedly; but never succeeded in finding a single pebble of Wealden sandstone.

We have seen that the gravels of the Medway tributaries contain materials of the same nature as the rocks wherein they rise, or over which they run; and when we compare this fact with that just stated regarding the Darent, it is impossible to conceive a stronger argument in favour of the fluviatile origin of these various gravels—by rivers flowing in their present direction.

If the higher gravels of the Darent and Medway were alike due to rivers or ocean currents flowing from the north, or to a great river or rushes of water flowing from west to east, why should they so entirely differ in character?

The gravels of the eastern and western branches of the Stour differ remarkably in character. The gravels of the eastern branch closely resemble those of the Darent:—they have no Wealden pebbles. Those of the western branch resemble the gravels of the Medway Lower Greensand area:—they everywhere have Wealden pebbles. Is it at all likely that these two sets of gravel can have had the same origin? If they, or the higher parts of them, were brought by a current from the north, flowing through the Chalk gorge, or by a great river flowing from the west, why should they thus differ in character? Why should the gravel at Kennington literally swarm with Wealden pebbles, when that of Willesborough (only two miles distant) does not contain a single one?

There can be but one answer to this inquiry:—they are the gravels of different streams (see fig. 26, p. 171).

The explanation already given (p. 293) as to the comparative rarity (not absence) of Wealden pebbles in the Medway gravels near Aylesford, does not suffice here. For those gravels of the Stour which have no Wealden pebbles are not the lowest of the series. That at Willesborough, where there are no Wealden pebbles, is at about the same level as the gravel at Ashford, where Wealden pebbles abound. The gravel at Warren House is at least as high as any on the western part of the Stour Valley; yet

not a single Wealden pebble has occurred here, whilst there is no section in the western part where such pebbles may not be found.

Although such different sets of gravel must certainly have been formed by different streams; yet, owing to the exceptional character of the Lower Greensand area in the Stour Valley, the fact cannot be as completely demonstrated as in the cases already considered.

Most of the streams which feed the eastern branch of the Stour rise at or near to the Chalk escarpment, and flow in a south-easterly direction into the main eastern branch, which *now* runs along the edge of the Weald Clay, in a west-north-westerly direction, to Ashford. We have already noted the line of outliers of Hythe Beds to the south of this, and the likelihood there is that these outliers represent an old line of escarpment (see pp. 235 and 252). When the gravels between Warren House and Willesborough were deposited this part of the escarpment may have been entire; certainly the Weald Clay would not be exposed along where is now the valley south of Merstham, for that valley could not then have existed. The stream then ran where the gravel patches now are, and if the escarpment on the south of it were entire there would be no streams flowing into it from the Weald Clay. The stream has gradually denuded its bed on the south of these gravel patches, down to the Weald Clay. If there are any gravels *along the borders* of this eastern stream, they would of course contain Wealden pebbles; but I am not aware of any gravels there.

The western branch of the Stour is also mainly fed by streams which rise at or near to the Chalk escarpment. Had the ancient Lower Greensand escarpment been entire here, as we suppose to have been the case with that on the east, no Wealden pebbles could have found their way into the higher gravels near Hothfield Common, &c., but they *are* found there. The Wealden pebbles at and north-east of Ashford could easily have been introduced by a stream on the west of Kingsnorth.

Possibly, too, the north-eastern branches of the Beult are robbing the basin of the Stour, just as the north-western branches of the Eden are robbing that of the Darent. This would allow a greater area of Weald Clay in the old Stour Valley than we now find there. The patch of gravel mentioned on p. 169 gives some countenance to this view; it contains apparently Wealden pebbles only, and would have been formed by a tributary of the Stour flowing from the Weald Clay.

It is not unlikely, but indeed highly probable, that the former Physical Geography of the Stour Valley was such as is here sketched out; but this cannot be proved. All we can say is, that no other arrangement of the stream valleys then that suggested, can in any way explain the distribution of the gravels.

Before leaving this part of the subject, we may note one matter connected with the higher gravels of the Darent and the eastern

Stour, which requires mention. The gravel on Limpsfield Common, at the western end of the Darent valley, is coarse, and not altogether what we would expect a river-gravel to be. It lies moreover *on the watershed*, and could not of course have been made by the Darent if the drainage area had always been what we now find it. The gravel at Warren House, at the eastern part of the eastern Stour, very much resembles this; but it is well within the Stour valley. The two sets of gravels are, however, remarkable for their extent, they are both larger and thicker than any other patches of gravel lower down the valleys. It may be that they have suffered less denudation than those lower down, and have therefore been able to maintain their size and thickness.

If the gravel at Limpsfield Common has been deposited by the Darent, that river must have taken it rise further to the west or south-west than now. That is to say, it must have risen in a part of that country now included in the basin of the Medway.

This may have been the case; for if the Lower Greensand escarpment is now receding to the north, and if the higher streams of the Eden are wearing their way backwards, they can only do so at the expense of the Darent basin; the Medway basin gaining what the Darent basin loses.

Although, if there be any truth in the theory of subaërial denudation, such changes as those here described must have taken place, yet perhaps they hardly explain the difficulty. It is improbable that the higher streams of the Darent were ever able to form such gravel as that at Limpsfield, which is evidently only the remains of a larger mass. It is more likely that the gravel at Warren House was made by the Stour; but if any special explanation (other than that of ordinary river action) is required for the gravel at Limpsfield, it is likely that the same might reasonably be applied to this.

The gravel at Limpsfield is 500 feet above the sea, whilst the highest point of the Chalk escarpment in this district is 876 feet, that of the Lower Greensand escarpment is 810 feet; these crests are free from gravel. Therefore the gravel at Limpsfield, although now on the watershed, is decidedly in a hollow as regards the neighbouring escarpments. The gravel at Warren House is somewhat over 300 feet above the sea, the Lower Greensand escarpment near Aldington is 350 feet or more, and the Chalk escarpment nearly 600 feet; so that here again the gravel, though capping a hill, is in a hollow as regards the escarpments.

If we suppose that any other action than that of rivers has made these gravels, it must have been one which effected a wide area; and if so, why do we not elsewhere find such gravel? If we suppose that the Chalk escarpment has since receded, and that any gravel which was deposited there has been collected into the true river-gravel; this will not apply to the wide area of Lower Greensand in the Darent valley. Somewhere on the Lower Greensand plateau, at or near the 500 feet contour, we should find remains of this gravel; for denudation on the *dip-slope* of

plateaus has done but little; its effects are chiefly shown in the long valleys which furrow them. This is well seen in the great gravel plains of Hampshire, of which MR. CODRINGTON says:*—

"The denudation which the surface of the country has undergone since the deposition of the gravel on the plains is as remarkable for its partial character as for its extent. Large areas of the plains at the highest levels appear to have remained quite unchanged, while close by deep valleys have been scooped out, and high escarpments have been formed by what cannot have been any other than subaërial causes, and while large tracts of land have been gradually removed by the action of the sea on the neighbouring coast-line."

Again, why is there no such gravel near the eastern watershed of the Darent, or over the Lower Greensand district of the Medway? Supposing the gravel at Limpsfield and that at Warren House to be due to one cause, we surely ought to find something like it in intermediate areas. The former being 500 feet high, and the latter somewhat over 300 feet, we ought near Maidstone to find gravel at about 400. But the highest gravel of this district is not much over 300 feet, and it is of a different kind. So too in the western part of the Stour, the gravels which, judging from their height, should serve to connect that at Warren House with that at Limpsfield, are again of a different kind, for they everywhere contain Wealden pebbles.

MR. SEARLES WOOD, JUNR., has stated as an objection to the gravel at Warren House being of river origin, formed by the present stream, that it contains numerous Tertiary pebbles, whereas there are no Tertiary outliers or pebble-beds along the neighbouring chalk escarpment. This argument is certainly very strong, but it is not quite conclusive.

The pebbles may have been derived from the old marine plain; or in the following manner:—

All along the Chalk escarpment of East Kent, but particularly on the east of the Stour, there are patches of sand and ironstone, which by some geologists are believed to be Crag,† but which others regard as Lower Eocene.‡ MR. WHITAKER is inclined to regard them as "transgressive parts of the Woolwich and Oldhaven Beds."§ Now the Oldhaven beds are remarkable for their great variations in structure over small areas. At Boughton-under-Blean they partly consist of sandy ironstone, which, lithologically, closely resembles that at Lenham; whilst a little to the south there are 30 feet of pebble-beds on the same horizon. The pebble-beds of Plumstead, Blackheath, Chiselhurst, &c. are of the same age, and so probably are those outliers of pebbles which occur near the Chalk escarpment in East Surrey. If the sands of Lenham and Paddlesworth be of the same age, it is not unlikely

* *Quart. Journ. Geol. Soc.*, vol. xxvi. p. 548.

† See the description of them by MR. PRESTWICH, *Ibid.*, vol. xiv. p. 322.

‡ MR. BRISTOW, *Ibid.*, vol. xxii. p. 553, (also Mr. Godwin-Austen).

§ *Ibid.*, vol. xxii. p. 430. They are shown on the Geol. Survey Map, Sheet 3, and they are described by MR. WHITAKER in *Mem. Geol. Survey*, vol. iv., Part I., p. 336.

that in their range further south they might contain masses of pebble-beds, which the recession of the Chalk escarpment has destroyed. I merely offer this as a possible, though not very probable, explanation; for it must be admitted that these gravels under any theory are difficult to account for, and their origin must for the present be left undecided. But whatever may be the origin of these two patches of gravel—that at Limpsfield and that at Warren House—there is no reason to doubt that the gravels lower down the valleys of the Darent and the eastern Stour are of true river origin, deposited by the streams flowing as they now do. They may of course be largely made up of the waste of the higher gravels, but that does not at all affect the main question which we have been discussing, which is, the amount of subaërial erosion which the river gravels prove.

As regards the recession of the Lower Greensand escarpment referred to above, we may here remark that the Medway valley must necessarily have increased at the expense of the Darent; and therefore that the Medway basin is larger now than when its higher gravels were deposited. But although this must have been so, the Wealden part of the Darent basin is not, on this account alone, necessarily smaller than formerly. For the Chalk escarpment, which bounds it on the north, has also receded; and whether the Chalk or the Lower Greensand escarpment recedes most rapidly, will depend upon the dip of the beds of each, and upon other circumstances. But, seeing that the Darent basin as a whole is bounded on the north by the Thames, it certainly is diminishing in size; for the recession of the Chalk escarpment is lessening the Chalk area. This is a point of great and general importance; for, wherever an escarpment is the watershed between two main drainage areas, one of these areas is necessarily increasing at the expense of the other.*

This is not a "reversal of drainage," or what is generally understood as such. It is merely the highest streams of one river basin eating their way backwards and taking some of the springs and surface drainage of its neighbour. By a "reversal of drainage" is generally understood a change in the direction of the *trunk drainage*; a river flowing, say, from north to south, being by some means made to flow—still as a river—from south to north.

There is not the slightest evidence that such a reversal of drainage has ever occurred, nor is it in the least degree likely that such ever can occur. The greatest changes of drainage which we can attribute to rivers is where one, by denuding its bed or

* To give a few instances:—The Bedford Ouse and the Bristol Avon are robbing the Thames, by the recession of the Chalk escarpment; whilst the Upper Avon and the Severn itself are robbing the Thames by the recession of the Inferior Oolite escarpment. In a similar manner the Meuse is robbing the Seine. Since the foregoing was written, PROF. RAMSAY'S paper on the "River Courses of England and Wales," has appeared (*Quart. Journ. Geol. Soc.*, vol. xxviii. p. 148, 1872). The recession of escarpments is fully explained in that paper; and also in the same author's Physical Geology and Geography of Great Britain, 3rd Ed. chap. viii. and xiv. See also COL. GREENWOOD'S "Rain and Rivers." 2nd Ed., p. 67.

destroying its banks, opens to itself a shorter outlet, or in this way falls into another river. But in these cases the river only forsakes one bed for another, the stream does not return upon itself. A change in the outfall of a stream may also occur by the cutting back of the coast line, as in the "Chines" of the Isle of Wight. Mr. CODRINGTON* supposes that the streams in the Chines on the south-western coast of the island were originally tributaries of the Yare, which carried their waters out at the north side of the island. Similarly, Shanklin Chine would have been a tributary of the Brading. The coast line has intersected these streams in their higher parts, and their waters fall direct into the English Channel. But the streams run *in the same direction* as before their having been cut deeply down into "Chines" near the shore.

To sum up the evidences of denudation afforded by the river-gravels we find :†—

1st. That the gravels of the main trunk valley always contain pebbles of the rock formations drained by that river, and no others.

2nd. That the gravels of each tributary stream likewise contains pebbles of the rocks drained by that stream, and no others.

From whence we infer that the gravels are the products of those several rivers or tributaries flowing in their present directions.

3rd. That undoubted river-gravel occurs at all heights, from the present level of the river up to 300 feet above that river.

Subaërial denudation has therefore excavated the valleys to a depth of *at least* 300 feet.

But a denudation of 300 feet in the lower part of the Medway valley represents more than half that denudation of the Weald which we refer to subaërial causes.

We cannot expect to find any *direct evidence* that the escarpments have been formed and worn back by subaërial agencies. We can only show, 1st, that there is no proof whatever of any other agencies having done the work; 2nd, that all other agencies with which we are acquainted are inadequate to the work done; 3rd, that the whole features of the district are such as can readily be explained by subaërial denudation. But the river-gravels are most valuable indirect evidences of the subaërial origin of escarpments. For when the River Medway ran at 300 feet above its present level, the escarpments, and the plains at their bases, could not have occupied their present positions. Rivers run at the lowest levels of a country, and all around them there is higher ground; therefore the Gault and Weald Clay valleys must have

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* *Loc. cit.*, p. 541.

† See Plate vii. (opposite p. 289). If the river origin of the gravels at the east end of the Stour be denied, that river must be excluded from the following generalisation. The Darent need not be excluded; for whatever may have been the origin of the gravel on the watershed at Limpsfield, all the gravel *within* the valley of the Darent has been derived from the waste of the Chalk and overlying Pebble-beds, or from the Limpsfield Gravel itself.

been *at least* 300 feet higher than now, and this could only occur by the Lower Greensand and Chalk escarpments stretching further south than now.

In the great deposits of brickearth near Maidstone and Hadlow, we have some evidence that these escarpments did formerly extend further to the south. At Snodland, where streams fall into the Medway previous to its passage through the Chalk gorge, there are now heavy and frequent floods. The same thing occurs at Yalding, where the streams collect previous to the passage of the river through the Lower Greensand gorge. It is in fact a general rule with rivers, that the greatest floods occur just where the transverse valleys breach the escarpments; for there the drainage of a large area, carried by several streams, is concentrated into one channel. The great brickearth deposits of Maidstone and Hadlow are the result of the floods of the River Medway, when it ran at a higher level than now; and when the gorges of the Chalk and Lower Greensand escarpments were further to the south.

Although by the river-gravels we can only actually *prove* subaërial denudation to a depth of 300 feet, yet it would be illogical to assume that as the limit of such denudation. The words of PLAYFAIR may appropriately be quoted here:—"The changes which have taken place in the courses of rivers, are also to be traced, in many instances, by successive platforms of flat alluvial land, rising one above another, and marking the different levels on which the river has run at different periods of time. Of these, the number to be distinguished, in some instances, is not less than four, or even five; and this necessarily carries us back, like all the operations we are now treating of, to an antiquity extremely remote; for, if it be considered, that each change which the river makes in its bed, obliterates at least a part of the monuments of former changes, we shall be convinced, that only a small part of the progression can leave any distinct memorial behind it, and that *there is no reason to think, that, in the part which we see, the beginning is included.*"*

* Illustrations of the Huttonian Theory, p. 103, 1802.

CHAPTER XVII.—RECENT GEOLOGICAL CHANGES.

Changes in the Coast Line.—These are of two kinds, loss and gain. Loss of land is due to the degradation of the coast line by the waves. Occasionally, too, land is lost by an irruption of the sea over low lands, and many historical accounts of the loss of land can be explained in this way; but in such cases the sea only takes back what had formerly been reclaimed from it.

The town of Folkestone has suffered much from the sea. LAMBARDE speaks of "the continuall warre, which the sea maintaineth against it." "For that violently washeth, and by peece meale wasteth it so, that not onely the nunnerie which stood 28. pearches from the high water marke is now almost swallowed up; but the castle . . . . and foure of those five parish churches, be departed out of sight also. Onely some broken walles . . . . do remaine, and the names of the parishes of our Ladie and Saint Paule, are not clene forgotten."*

The following description is by MR. DREW:—†

"At Folkestone all that flat land on which the Gasworks, the Pavilion Hotel, &c. &c. are built consists of shingle, collected by the building out of the west pier of the harbour. When the shingle had reached the extremity of the pier and the beginning of a short work at the south-east point called the Horn, it washed round and made a bank outside the east pier, and began to fill up the harbour so much that except at spring tides vessels drawing nine or ten feet could not enter.‡ In this state the harbour was bought by the South-eastern Railway Company in 1843, and they adopted the plan of continuing the Horn, and carried it out so far and at such a height that all the shingle is intercepted, and has formed a piece of land still growing, which has been of great value, the Harbour Station and the Custom House being built on it. When once the harbour was cleared of the shingle and mud that had accumulated it remained free, or at all events whatever finds its way in is scoured out by the return tide and the rush of the pent streams. Another consequence of these works is that the shore at the East Cliff has had all its beach washed away to the east, and gets no further supply, so the cliff is there being denuded, though it is now in part protected by masses of the hard stone that occurs in the Lower Greensand, which have recently fallen and make a kind of natural breakwater."

The cliffs of Winchelsea, Rye, and those further north, were subjected to the wear and tear of the waves before the sea was shut out from them; but now there is nothing near these old cliffs but marsh land and shingle.

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* Perambulations of Kent (written in 1750), 1576; quoted from Ed. 1826, p. 154.

† Mem. Geol. Survey, Sheet 4, p. 24, 1864.

‡ Official report to the Engineer-in-chief of the South-eastern Railway Company, by ALEXANDER SWAN.

The following is an account of the value of the land destroyed between the years 1292 and 1340. All the cases mentioned on the Wealden Coasts are marshes over which the sea had flowed:—*

	Value of Tithes in 1292. £	s.	d.
In Guestling—Sneppesmarsh—totally submerged by the flow and ebb of the sea - - -	2	2	8
„ Fairlight, Mersehammarsh—laid waste by the sea - - - - - - - - -	0	13	4
„ Pett, Marsh submerged by the sea - - -	1	6	8
„ Icklesham, Rynggeresmarsh—totally submerged	2	9	8
„ Brede, Gateberghemarsh - - - -	0	13	0
„ Salehurst and Udimere—Gateberg Marsh ? -	4	15	0

Romney Marsh.—This has already been described as a flat area of alluvial land, bordered in some places by shingle, in others by blown-sand; and in one part, near Dymchurch—where such natural barriers are absent—by a sea-wall. There is one important fact to note as regards the shingle (and which is also the case with that of Langley Point); it has chiefly accumulated to the *windward* of tidal harbours, whilst the blown-sand has accumulated to leeward of these harbours. There are three great areas of shingle at or near Romney Marsh. The most westerly of these —that around Camber Castle—is to the windward of the present mouth of the Rother, on the east or leeward side of the mouth there is blown-sand. Dunge Ness is to the windward of an old mouth of the Rother, where was formerly the harbour of Romney; on the east of this there is blown-sand. On the south of West Hythe there is shingle, which was formerly much more extensive than now; its "fulls" or ridges curve well round to the north-west, as though to a harbour here; on the north of this there is again a little blown-sand.

It is at the place last mentioned that antiquaries have for a long time placed the ancient outlet of the Rother (then called the Limen); and certainly the fulls of shingle and the blown-sand lend some support to this; but it is remarkable that no trace of the ancient channel is to be found along the northern side of the marsh, where the river is supposed to have flowed from west to east. Moreover the level of the marsh falls from east to west along its northern side. At West Hythe it is 7 feet 8 inches below high-water mark of medium spring tides; north of East Bridge Chapel 9½ feet; south of Bilsington 10½ feet; and at Appledore Dowls 13½ feet.† These facts have led Mr. J. Elliott and Mr. C. Roach Smith to reject the common belief; and they suppose that, before the marsh was reclaimed, a scour of water drained

* Blaauw, Remarks on the Nonæ of 1340, as relating to Sussex. *Suss. Arch. Coll.*, vol. i., p. 58.

† These heights are taken from the Maps of Romney Marsh (by Mr. Jas. Elliott), in Mr. T. Lewin's "Replies to the Remarks of the Astronomer Royal, ... upon 'the Invasion of Britain by Julius Cæsar.'" 8vo. Lond.

out at ebb tide near Lympne (Portus Lemanis), but that the River Rother itself (the Limen) always flowed to Romney.*

It is however by no means unlikely that the ancient Rother had more than one mouth. There may have been one at Lympne, one at Romney, and one near Rye.

The cause of the original formation of Romney Marsh is altogether unknown. It is usually attributed to the "meeting of the tides;" but as this takes place not at one definite point but over a rather wide area, and as shingle beaches and alluvial flats occur where no tides meet, the explanation is not wholly satisfactory.

Some years back MR. JAS. ELLIOTT published an account of Dymchurch Wall,† and in this paper he described some supposed islands of Hastings Sand near Romney, to the presence of which he supposed the silting up of the area might have been due. MR. F. H. APPACH has more recently referred to this, and attributes the formation of the Marsh to this cause.‡ It may, therefore, be well to point out that this is an error, and that there is no evidence of any such island in the Marsh. Mr. ELLIOTT had observed some ferruginous sand, sometimes hardened into a sandstone, which looked exceedingly like true Wealden sand; but a few years back a new drain was made through the place where this occurs, and he then saw that the whole is alluvial. Mr. ELLIOTT obligingly directed me to the spot where this was exposed (nearly half a mile due north of Hope Chapel), and there can be no doubt that the sand there seen is entirely of recent date.

The following pages I reprint from MR. DREW's Memoir on Sheet 4, which includes the whole of Romney Marsh:—

"There is abundant evidence that the sea extended at a very late geological period over the whole of what is now the Marsh, and ran inland for many miles; and there are historical proofs that a harbour existed at the foot of Lympne Hill. It is also known that ships used to sail along the river past Appledore further up the country.§ Besides this, every here and there in the marshes, even as high as Newenden, sand is met with different from any that occurs in the country drained by the river Rother, and evidently sea-sand. Lastly, there is the fact that the whole of this marsh-land, as far up the Rother as Bodiam, would be overflowed by the tide at high water if it were not for artificial embankments. This district then which now makes a promontory was once a bay with creeks and long inlets.

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* "Notes on the Original Plan of the Castrum at Lymne, and on the past and present state of Romney Marshes," by J. ELLIOTT; appended to MR. C. R. SMITH'S Report on Lymne, 1852, (privately printed).

† *Proc. Inst. Civ. Eng.*, vol. vi., p. 469, 1847.

‡ Caius Julius Cæsar's British Expedition from Boulogne to the Bay of Apuldore, and the subsequent formation geologically of Romney Marsh. 8vo., 1868, p. 16.

§ In the beginning of the 16th century a licence was given for the burial of shipwrecked men at Small Hithe, south of Tenterden.

"It will be remembered that underneath the clay and peat of the marsh loose sand has been found, in one place even to a depth of 70 feet.* No one has yet determined how much deeper the sand may be, but this depth of 70 feet corresponds with that of the nine-fathom line on the Admiralty Charts, in which the soundings are reckoned from low water. Now it is likely that all the space, say as far as the centre of the Marsh, is occupied by 70 feet or more of these recent deposits, for if any ridge of secondary rocks lay close underneath it would probably be prolonged out to sea, deflecting the nine-fathom line; but as this line has a nearly straight course from outside Rye Bay to Dunge Ness, and from thence north-east towards Folkestone, it may be inferred that the projection of the land at Dunge Ness is due to the accumulation of sea-sand, shingle, and alluvium. Romney Marsh seems, therefore, to have been formed as follows:

"The first stage was probably a shallowing and filling up of the bay by the accumulation of silt to such an extent seaward as to make a sand-bank or series of sand-banks exposed at low water. The origin of this accumulation is not quite clear, but it was probably caused by the meeting of the two tidal waves in this part of the channel, or else by a local tidal eddy produced by the form of the coast line. When in this way the bay had shallowed considerably the fine clayey and loamy sediment of the Rother and the other streams that flow into the marsh began to be deposited on the sand, instead of being carried further out to sea, as had previously been the case. Plants then began to grow upon the newly formed surface, which probably extended much further seaward than it does at present, and may have been actually upheaved by oscillation of level, forming a plain well raised above the level of the sea. Forest trees flourished on this surface for the moor-logs in the peat have all the appearance of having grown on the spot. If this be so it follows that since that time there has been a depression of the land, because the peat that occurs at Appledore, and along the shore between Rye and Dunge Ness, and also that often found in sinking wells, is at too low a level for the plants to have grown at these places while the sea had access there.

"The amount of this depression cannot be determined for want of sufficient evidence. In later times it looks as if the long arms of the Marsh were made by the gradual sinking of the land and the letting in of the waters to the valleys, thus gradually filling them up with Alluvium; for they do not appear to have been at all denuded out or widened by the sea. The ground is cliffy only where the edges of the land face the Marsh.

"It would be interesting to know what was the extent of this old land surface, but as yet this cannot be made out accurately; it is certain, however, that the land extended further towards

* See p. 206.

the south-west than it does at present; the peaty mud along the shore is a proof of this, and one is tempted to think that it was continuous with the sunken forest that is seen on the fore-shore on the other side of Hastings. There is no reason to believe that any of the depression of land took place in the historical period, *i.e.*, from the time of the Romans downwards, for no human remains nor works of art have been found deep in the Alluvium, and all the changes recorded in history can be accounted for by the ordinary action of the elements at the surface. It is likely therefore that the deposition of Alluvium had raised the ground above the level of low water, either before the Romans left the country (as is most probable), or, at all events, not long after. For in the time when Kent was a kingdom, grants of pasture and woodland in the Marsh were made by the kings to different monasteries, and are recorded in the Saxon Charters. The Rev. Mr. Jenkins, rector of Lyminge, has favoured me with notices of some of these: one of the earliest is a deed* of King Wihtraed's, dated A.D. 697 and 700, granting to the monastery of Lyminge pasture for 300 sheep on the south of the river Limen, which was the early name for the Rother, at that time flowing out near Hythe. Again, in a grant of Æthelbert, dated 740, mention is made of Bishopswick on the Marsh and of Lydd Ripe.

"I have said that the Rother, then called the Limen, used to flow out at Hythe; Lympne was once a Roman station, called Portus Lemanis, and had a harbour kept open by the waters of the Limen. There are yet remains of the fortress in the ruined walls, of Roman masonry, of Stutfall Castle. Mr. Jenkins also tells me of a charter† by which King Egbert granted, A.D. 833, to the monastery of Lyminge a piece of land at Sandtun that was bounded on the south by the river Limen; Mr. Mackeson of Hythe recognised this place "Sandtun," as the same that is now called the Sandton, namely, that patch of Blown Sand between West Hythe and Butters (or Botolph's) Bridge. This charter then gives the position of the river at that date and also proves (or at all events makes it very probable) that this Blown Sand existed as early as the ninth century.

"It is likely that some of the most westerly of the shingle-fulls in that neighbourhood were formed at the time the river flowed out there, as they trend inland in such a direction as to make one think they then bounded the haven on the south, and from the sharpness with which they end on the coast it may be inferred

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* KEMBLE's Saxon Charters, tome i., p. 54, number xlvii.

† No. ccxxxiv. in KEMBLE's Collection (tome i., p. 308).

[With regard to these Charters it should be noticed that MR. C. ROACH SMITH claims some of them as referring to Lympne, not Lyminge; see his *Antiq. of Richborough Reculvers and Lymne*, 1850, p. 237. He says that the names Limingae or Liminae, which occur in these charters, "it would seem, must be considered as implying, in a general signification, the district from the present Lymne to the River Limene."—W. T.]

that they once extended further out to sea and have since been partially denuded.

"The Rother afterwards shifted its channel and flowed into the sea at Romney. At what time this alteration took place is not known, but it is likely that it was before the Norman Conquest. It was followed by a silting up of the old haven, which no longer had the waters of the river to scour it out. A further result was the accumulation of shingle, which at last, about 300 years ago, altogether closed the inlet. The lines on the map show the various positions of the shore at different times, and they can be very well seen, in a sort of bird's-eye view, from the hills behind the two Hythes. Granting then that the Rother began to flow to Romney about the tenth or eleventh century, we must try and trace its channel more exactly. In those days it flowed from Newenden round the north side of the Isle of Oxney, by Small Hithe and Reading Street, past Ebony (probably on the north) to Appledore, and from Appledore to Romney the course was along what is now the road joining those two places, which runs on a wide bank on a higher level than the marsh; this is called the Ree Wall. Here there was formerly a channel banked up on each side, and judging from the size of the Ree Wall, it seems probable that the river gradually raised its bed by depositing sediment, the banks being heightened in proportion, till at last even the river bottom came to be as high as the land on each side. Part, however, of the elevation of the centre may have been caused by a levelling of the banks when the old channel was filled up to form the roadway. Where this Ree Wall bounds Appledore Dowls there is a good instance of what occurs in many places on the Marsh, namely, a difference of level between two parts, the lower one ending against an abrupt slops or bank that bounds the higher. On the south the fields are about at the same level as the road, while on the north there is a fall of many feet to the low ground of the Dowls; and the reason of this is that when the land is once enclosed, and kept from the influence of the sea, it gets no further sediment deposited on it, but keeps at the same level, while that outside is always receiving fresh accessions of mud, &c., which raise its level, sometimes even in a long course of time to nearly the top of the wall that was made to keep out the sea from the first tract. Therefore the older the enclosure is the lower the land; that about Rye, the most recent of all, having been enclosed in 1833, is at a high level, only three feet below high-water mark of spring tides. The higher parts are mostly to seaward; those near the former shore, having been enclosed first, form the lowest part of the Marsh. When the Rother flowed down by the Ree Wall, the Romney was the port, and afterwards New Romney was built on a spit or island of shingle. Towards determining the date of this there is the fact that New Romney church has a very fine tower of Norman architecture. The banks of the old channel can be traced (where there is a dotted line on the map) to the

beginning of the town, and where they end there are some heaps or earthworks that are said to have been the forts that defended the entrance. The trend of the shingle from Globsden Gut to Romney, and the corresponding curve on the other side of the river mouth from Lydd northwards, render it likely that these banks were formed when the waters of the Rother flowed out there and kept a clear channel between the two towns. Following then the 'shingle-fulls' from Jacks Court, we find that the ridges continuous with them are either those joining Lydd and Dunge Marsh Court, and leading to the south-east, and then curving round to the south-west, or if not, that which goes from Lydd to Abnor Pit, or else an intermediate one. All that great mass of shingle, therefore, forming Dunge Beach, which lies to the east of the first-mentioned line, was, as can be seen by the direction of the ridges, formed later, and must have been brought round the Point, and collected since the Rother first came to Romney.

"Here it may be well to inquire as to the form of Dunge Ness at different periods. The shingle having come from the west and lapped round, so as to make the north and south 'fulls,' it is plain that the most westerly of these is the oldest. If, then, we suppose each 'full' in succession on the east and south-east to be removed, the remainder will give us the form of the Point at different periods. Taking away, then, all that is marked Dunge Beach, the line of beach from Lydd to Dunge Marsh Court, and from there round to the shore between Abnor Pit and the Gut, will, as before stated, represent the Point about the tenth or eleventh century. The 'fulls' that stretch from Lydd Ripe towards Wigmore Pit were formed earlier, and as these do not curve round to the west, but, after running straight for a mile or two, abut against the present beach, they must have formerly extended further seaward and have had their ends washed away. The dotted line south of Abnor Pit, which curves round to the west, is an attempt to show what was the form of the Point when the most easterly of these 'fulls' was the last that had been made;* and the line leading out from Holme Stone represents what may have been the position and form of the Point when all east of that was sea. The same kind of argument holds good for the line still further west. Lydd Ripe having been, as we know, in existence in the eighth century, the most easterly of the dotted lines may represent the Point at that period, or even earlier. The relation of the present beach to these old 'fulls' shows that there has been great destruction of the old shingle beaches from the weather side of the Point, and that a great part of the beach on the east is the spoil of earlier 'fulls' on

* "The part of the Alluvium marked *The Brooks* bears also the name of 'Old Haven.' If it was ever a harbour, it must have been so at a very early period, when perhaps the 'fulls' at Wigmore Pit were the most easterly, and the sea flowed round them on the north and back towards where the coast-guard station now an is, making almost land-locked harbour."

the west; that, indeed, the pebbles have shifted on from west to east in stages, at one time collecting and remaining probably for centuries, and afterwards being again invaded by the waves and carried further on. There is a circumstance already mentioned not very easily accounted for, viz. that the shingle at Holme Stone and other parts is at a lower level than the present beach. It may be that the land has been slightly depressed since its formation, but I think it more likely that the reason of it is connected with the varying level of the tides, and that perhaps the spring tide did not rise so high here at that time; or possibly each 'full' did not remain for so long a time as the outermost one, and therefore had less chance of the combination of heavy sea and high tide which is so effectual in piling up the beach. The subject, however, still requires accurate working out.

"We have now to trace the changes of Dunge Ness through the later periods. No accurate maps are known before the time of Queen Elizabeth, during whose reign a chart was made of the Marsh and the Ness, and from that and other authorities Mr. Redman has deduced several very important facts, which are given in a paper read before the Institute of Civil Engineers. It appears from his researches that in Queen Elizabeth's time the distance of the Point from Lydd Church was just three miles, whereas in 1844, when the Admiralty Chart was made, it was three miles and seven-eighths. Reckoning from 1617, when an accurate map was published (by Cole), 'the average annual increase during two centuries has at least amounted to nearly six yards.'* The Ordnance Survey of this district is said to have been made in 1794, and the map was published in 1816. When I surveyed the district in 1860, and inserted all the 'fulls' or shingle ridges on the previously featureless Ordnance Map, I found that in 66 years the point had grown about 360 yards, always supposing, which is doubtful, that an Ordnance Map so old can be depended on as giving precisely the true form of the old coast. In like manner, at Christmas 1860, I found that on the north of the Point the shingle had increased since the Admiralty Survey; and for the guidance of future observers I may remark that the point itself was then 420 yards from the Lighthouse in a direction 8° north of east, while the nearest point of the shore to the Light was 185 yards from it in a direction S. 20° E.†

"I will now return to the river Rother, and add a few more facts regarding its former channels. The Rother continued to

* *Proceedings of the Institute of Civil Engineers*, vol. xi. (1852).

† [It appears by a survey made for the Trinity House in October 1871 (by A. Beazeley) that the point was then 1,230 feet from the outer wall of the lighthouse, (or 1,287 feet from its centre), in a direction 1° S. of east (true). This is measured to the top of the most recent full; high-water mark of spring tides is 70 feet further. The nearest point of the shore was 560 feet, from the outer wall of the lighthouse to the top of the most recent full, in a direction 10° E. of South (true). The shingle a little to the east of the point here measured is not constant in character, sometimes largely increasing in the course of a few tides and then as rapidly diminishing. The line given above is that along which the permanent and maximum increase takes place. W. T.]

flow out at Romney, keeping that port open, until the middle of the 13th century, when some destructive storms breaking down the walls, probably accumulated sand-banks at its mouth, and forced the river to seek a new channel. It then changed its course at Appledore, and fell into the sea at Rye. From that time New Romney decayed as a port, and it was not long before the harbour was disused; at the present day Romney Hoy, as this inlet is called, is nearly filled up with sand and mud, being only covered by the sea at high water about the period of spring tide. In the same century the old town of Winchelsea was destroyed by the waves, having been built on the sands or shingle not far from the present mouth of Rye Harbour, but its exact position is unknown, and it may have been somewhere out at sea beyond the present coast line. Cole's map of 1617 shows the Rother flowing in what he calls 'Appledowre Channel,' from the village of that name, to Knock House, and from there to Rye. Its course corresponds with *High Knock Channel* engraved on the Ordnance Map.

"Winchelsea Castle (or Camber Castle as it is usually called) was built by Henry VIII. to defend the harbour, which at that time must have opened to the sea, in such a manner that the car of shingle in front of the castle was then the shore. It would seem that shingle afterwards formed in 'fulls' to the east and gradually drove the river mouth in that direction. In 1617 the shore on the east side of the harbour (which is all that is depicted on Cole's map) ran from East Guildford towards Broomhill of the map (formerly a town, but destroyed by the sea in 1287), and returned by Camber to a point near where the word *Harbour* is marked on the Ordnance Map. This shows us that the shingle on the north-west of the Lighthouses did not exist in 1617, nor probably did that which extends from the church at the harbour towards 'Pier Head'; and it is quite certain that the long spit south-east of this had not been formed at that time.*

"About the middle of the 17th century a new cut was made for the Rother from a mile or two east of Newenden through Wittersham Level on the south of the Isle of Oxney to near East Guildford, and the river is still kept to this channel. In the last century a cut was made, beginning at Rye and passing near Winchelsea, that brought the waters of some small streams, and for a short time those of the Rother also, to a point three miles south of Rye at the very edge of this map [Sheet 4]. This channel, which

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* [It would seem from the following lines, published in 1653, that at that date the sea came close to Camber Castle at high water :—

"A castle stands i' the sands, enduring flaws,
Gusts, tempests, storms, and time's devouring jaws :
In twice twelve hours, 'tis twice embraced round
In th' arms of *Neptune*, seeming to be drowned :
And when the floods are eb'd into the main,
Three miles in sands 'tis compast round again."

JOHN TAYLOR, "The Certain Travailes of an uncertain journey."—W. T.]

is called Rye New Harbour, did not remain in use many years, and on its abandonment the old channel, which forms the present harbour, was readopted; the last mile of the former channel is now turned into grazing land.

"The building of the Pier Head at the New Harbour has had a curious effect on the movement of the shingle. . . . . The shingle collected on the west side of the piers till the bight was filled up and then passed the pier heads, making a long narrow spit with the 'fulls' going diagonally across it, and leaving a nook or inlet of water between the spit and the older line of shingle. At the time the Ordnance Map was made (published 1816) this spit had only got a little more than half a mile to leeward of the pier; in 1840 it had nearly reached the present harbour, making the innermost of two claw-shaped banks marked on the map, and in 1858 the outer one had been formed, reaching past the new pier of the harbour and threatening seriously to impede the navigation.* The nook or inlet mentioned above has at the same time been gradually filling with sand and mud, and a good many acres of it have been banked in.

"It only remains to speak of a few more very recent changes, and of those that are now going on along the shore.

"The martello towers along the coast were built about 1808; at Rye Harbour there were two, Nos. 28 and 29; No. 29 was washed down about the year 1822, and a good deal of the shingle to the south-west of where it stood has also been swept away by the sea. No. 28 was with difficulty preserved, but now, from the formation of the new point of shingle, it is well protected and never exposed to a heavy sea.

"On the other side of the harbour, the hillocks or dunes of Blown Sand have a good deal increased during the last 70 or 80 years. A ridge has been formed in front of the public-house (near the *b* of *Harbour* on the map), and at one time the sand was being blown over the rich land about Camber, but now it is held together by the growth of the *bent-grass* which was sown there for the purpose. At the present time the sand-hills are increasing somewhat on the seaward side. From Camber to Dunge Ness the land is losing a little; some of the coastguard houses have been washed down, and so have two batteries (west of Dunge Marsh Gut) which were standing at the time of the Ordnance Survey.

"At the part of the shore to the south-east of the Lighthouse the waste and supply are perhaps equally balanced, while at the Ness and north of it as far as Great Stone Point the land is increasing. The shingle must pass from that Point to Little Stone across a bar of sand which exists in front of the Hoy. I hear from coastguard men that beach pebbles are sometimes seen on it. The trending inwards of the 'fulls' at Little Stone

* "For the details of this, both here and on the map, I am indebted to the survey made for the Rye Harbour Commissioners."

(somewhat hidden by the Blown Sand) is probably due to easterly and north-easterly winds, which drive the beach round to a position from which the waves, raised by the southerly winds, cannot remove it. It seems likely that in time the Hoy will entirely silt up, and the two Points will meet. Towards Globsden Gut the shore has receded a little lately, and the martello tower there (No. 26) is almost standing out in the sea. The coast about Dymchurch is not gaining at all, and of course the wall which is kept in good repair, prevents any loss. The shingle, I am told, travels along it with great velocity when the waves are high. The beach in front of Hythe is gradually losing, as the waste is not compensated by a supply of shingle from the south-west, that which comes round Dunge Ness being for the most part deposited on the shore before reaching Romney."

F. DREW.

Coast between Winchelsea and Pevensey Level.—On the south of Pett Level the shingle, which is a continuation of that described above on the west of Rye Harbour, is laid up in a series of fulls which strike the modern full obliquely. It is therefore evident that these once extended much further to the south-west. This wide beach terminates at Cliff End, and from thence westward to Hastings the beach is narrow, being all of modern date.

At Hastings the shingle is arrested by groins for the protection of the town, without them the beach would rapidly travel along to the east and the sea would advance upon the land.*

There is a rather broad tract of shingle at Bulverhithe, forming the seaward face and protection of the broad alluvial meadows behind. Immediately to the west of this there is the slight promontory on which tower No. 43 is built. Here there is little or no shingle, and what little may accumulate here at times serves rather as an aid to the sea in its advance upon the land than as a protection from it.

Still further west there is a continuous band of shingle protecting the low cliffs from rapid degradation, although the sea all along here is encroaching gradually and the shingle slowly progresses landwards. In many places the shingle dams back little streams, which flow down from the land, crossing in a nearly straight line between the two small prominences on each side of the stream's mouth. Behind this shingle the water accumulates.

Pevensey Level and Langley Point.—Probably the same causes have operated here as at Romney Marsh in producing the deposition of the Alluvium; but here there are certainly islands of Wealden Beds just projecting from the Alluvium, which mark the higher parts of the old submerged land-surface. The shingle is

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* Some interesting and valuable remarks upon the shingle of Hastings have been made by MR. BECKLES and DR. BOWERBANK. (See their papers in Appendix I. under the year 1870.)

to the windward of the old harbour of Pevensey, and to the leeward of the same there is some blown sand.

At one time the sea washed the base of the hill on which Pevensey is built; this is now three-quarters of a mile from the shore. There was then a harbour of Pevensey on the east of the town, the mouth of which, by the gradual silting up of the shore, was prolonged to the south and south-east.

It is not known whether there was any shingle to the west when the mouth of the harbour was at Pevensey. Perhaps the collecting of this shingle was the cause of the silting up of the haven. But it seems doubtful if there was any great accumulation here as late as 1698, when a plan by COLLINS was made.* In the year 1736 a survey of the coast was made by DESMARETZ, from which it appears that the point stretched 1½ mile to the south-east, measuring from the main road at Anthony Hill in a line along the road which runs direct towards the present point. The distance now is seven-eighths of a mile.

The old fulls at the point, and to the east of it, strike the modern full obliquely, so that to get the rate of increase between 1698 and 1736 we must measure, not across the greatest width of shingle, but at right angles to the old fulls. The distance from the east side of Crumble Pond to the eastern edge of the shore shown by DESMARETZ is 1¼ mile, which gives an increase of 58 yards per year between the years 1698 and 1736. Supposing the maps to be reliable this gives the *minimum rate* of increase; for the shingle may not have begun to accumulate immediately after COLLINS' survey, and it may have been partially denuded before DESMARETZ'S survey.

But this is a rate of increase far in excess of what is known to occur elsewhere. The greatest rate of increase at Dunge Ness has been 8¼ yards per year; whilst, as we have seen, the *average* rate is only six yards. It is, therefore, probable that the old maps of the coast to the west are not to be relied on in this matter, and that a spit of shingle has existed to the windward of Pevensey Harbour for a long period.

The greatest known extension of this spit is that recorded in DESMARETZ'S map; since then it has been gradually diminishing.

MR. REDMAN estimates the yearly waste of the point as follows:—"From 1724 to the present time (1851) an annual average recession of 7·33 yards; from 1736, 10 yards; and from 1778, 10 yards. This is by comparing the high-water lines; if the low-water marks are taken, a greater result will be obtained, as the slope of the point was formerly much flatter."†

The recession of the shore on the west of the point has destroyed some of the Martello Towers which were erected in 1808. MR. REDMAN states that Nos. 70, 71, and 72, when erected, were respectively 177, 184, and 143 feet from high-water mark

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* *See* MR. REDMAN'S paper, to which I am indebted for the following particulars.
† *Proc. Inst. Civ. Eng.*, vol. xi.

of spring tides, but that in 1851 the footings of these towers were exposed; which gave an average annual decrease of about 4 feet.

In June 1869 I found that Nos. 71 and 72 were destroyed, the shore having receded behind them; the highest full at No. 70 was 15 yards behind (inland of) the centre of the tower; at No. 69 it was 12 yards behind; No. 68 had disappeared. The centre of No. 67, at Langley Point, was 54 yards behind the modern full. There is another full parallel with this, further inland, and 30 yards from it; 20 yards further inland there is another, not very well marked, which just touched the outside of No. 67 Tower.

The shingle to the north-east of the point is slowly increasing. The following measurements were taken in November 1864 when I mapped the old fulls; they may be useful in fixing the rate of increase:—The centre of No. 62 was 75 yards from the top of the most recent full; No. 66 was 68 yards, and No. 67 was 48 yards.

The Circular Redoubt (Tower No. 73) has long been threatened with destruction. Mr. Redman recommended "a pitched stone slope around the base of it" as the most effectual way to protect this redoubt. This has been done, and it would seem that the degradation of the coast has to some extent been arrested. According to the Admiralty Survey of 1844 this redoubt was at about the same distance from the shore as Tower No. 72; the latter has disappeared, whilst the modern full was in 1869 about abreast of the centre of the former.

The old and very indistinct fulls behind (or a little to the north-east of) this redoubt present the same curious differences of level with respect to the modern full as do the oldest fulls of Dunge Ness. Standing on the old fulls near the Redoubt one cannot see the horizon, it is quite hidden by the modern full; but in going eastwards, crossing successively the old fulls, and getting gradually on to those of later date, the sea comes into sight, and more and more of it is seen as Langley Point is approached. The oldest fulls here, as at Romney Marsh, are the lowest. Mr. Drew has suggested that this may be due to one of three causes (see *ante*, p. 309):—1st, a slight depression of the land; 2nd, each full not remaining long exposed to the gales and spring tides, so that the beach had little chance of being piled up; 3rd, a smaller range of tide formerly than now. As the cause, whatever it may have been, has affected the shingle of both Dunge Ness and Langley Point, it is not likely to have been the 2nd; the 3rd is improbable; so that the 1st, a slight depression of the land, is the most likely cause.

If this be truly the cause, then the low fulls of Langley Point should be of about the same age as the low fulls of Dunge Ness; but we have seen that the latter are 1,000 years or more old, therefore the former are probably of the same age. This agrees with what we have already said as to the likelihood of there having been a shingle beach here during a long period, although old maps give no evidence of its existence.

Some groins in front of Eastbourn are admirable examples of wasted labour. The shingle has in places retreated beyond them, and in other places passes on quite regardless of them. They have been constructed very near together, at distances varying from 10 to 40 yards.

Landslips.—The most important of these is that on the east of Folkestone, of which, though evidently of comparatively recent date, there is no historical account. The Chalk has slipped over the Gault and marly Upper Greensand, and has fallen in a huge mass of ruins known as "The Warren." This was evidently much more extensive in former times than now, for the sea is cutting away the fallen Chalk, and is eating its way further back into East Wear Bay. The summit of the Chalk cliff along the back of the undercliff is about 500 feet high; the highest point (Folkestone Hill) is 575 feet. Below the summit there is a nearly vertical face of Chalk, and then comes the great mass of fallen Chalk, through which the South-eastern Railway runs in deep cuttings.

It would seem likely that the movement of this undercliff has not even now altogether stopped, or perhaps rather that the influence of the slip has not yet ceased; for MR. DE RANCE tells me that the beds on the flat shore of East Wear Bay are slowly changing their positions; and that, looking from certain points on the east, some buildings near Folkestone can be seen across the depression between Martello Towers Nos. 2 and 3 which some years ago were hidden.

The land at Folkestone itself has not of late years given any signs of movement; but between that town and Sandgate there is a small undercliff, caused by the Folkestone Beds slipping over the soft and clayey Sandgate Beds. In the early part of the last century some extensive slips occured at Folkestone, which were described by the REV. J. SACKETTE in a letter to the Royal Society.* The slips occurred on the west of the town, probably where the small undercliff yet remains. SACKETTE says:—"The cliffs consist of great rugged sand-stones till we come to near a yard (at some places more) of the bottom, then we meet with what they call a slipe, *i.e.*, a slippery sort of clay always wet. Upon this slipe, at the bottom, they presume that the hard stoney sand above slides forwards towards the sea, as a ship is launch'd upon tallow'd planks." The sliding of the cliffs forced up rocks or small islands on the shore. This part of SACKETTE'S description is plain enough, but from other appearances described it would seem that the coast near Folkestone *as a whole* was then undergoing some changes of level.†

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* *Phil. Trans.* for 1716, p. 469. See also a paper by LYON in *Phil. Trans.* for 1786, p. 220, wherein the author throws some discredit upon SACKETTE'S description.

† Compare the account given by SACKETTE, with that (quoted from SIR R. WORSLEY) in SIR H. ENGLEFIELD'S Isle of Wight (p. 43), where similar changes are described.

Possibly some of the slips may have been indirectly caused by the removal of blocks of stone from Folkestone Cliffs for the building of Dover Pier; and, says SACKETTE:—" a very great Quantity of them were ship't in the time of Oliver's usurpation and carried to Dunkirk for the service of that Harbour."

Similar slips have occurred along the north side of Romney Marsh, where the old cliffs of Kentish Rag occur resting on Atherfield Clay. A remarkable account of one of these slips, which took place in 1725 at Lympne, is preserved in the Gentleman's Magazine for 1756.* The writer says the slip occurred during a very wet season. The side of the hill gave way, " raising by that means the flat at the bottom and letting the brow, with the farm house upon it, sink forty to fifty feet at least. What is remarkable it sunk in one night, and that so gently that the farmer's family were ignorant of it in the morning when they rose, and first discover'd it by the door-eaves, which were so jamm'd up as not to admit the door to open."

It seems exceedingly likely that the Roman Castrum at Lympne was destroyed by a landslip, and that the walls were in part covered up by fallen earth. The date of this slip is very reasonably placed by MR. THURSTON before the Norman Conquest; for LANFRANC partly built the Upper Castle and Church of facing stones from the Roman fortress, and would probably have taken all had they then been uncovered.†

Landslips have occasionally taken place along the Lower Greensand escarpment, chiefly on the south of Westerham and at Leith Hill. It seems likely that here and elsewhere the slip is due to a change of dip; the beds dipping for a short distance to the south instead of to the north as usual, so that the beds slide over the underlying clay, whereas if the northerly dip were constant the beds would have no tendency to slide.

The first work mentioned in the Bibliographical List (Appendix I.) is one by JOHN CHAPMAN, published in 1596 which gives " a most true report of the myraculous moving and sinking of a plot of ground about nine acres, at Westram, in Kent, which begun the 18 of December, and so continued till the 29 of the same month."‡ This slip was on the east side of the turnpike road at Cockham Hill. There were several other slips at the same time of from 34 to 65 feet.

In 1756 there was another slip which took place at Toys Hill, two miles to the east of Cockham Hill.

There is no record of the slips which have taken place at Leith Hill. EVELYN, in a letter to AUBREY (written in or before 1673), mentions the fallen earth on the southern face of the hill,

* By REV. W. GOSTLING, vol. xxvi, p. 160. The letter was written in 1727.

† C. R. SMITH's Antiquities of Richborough, Reculvers and Lymne in Kent. 1850, p. 249.

‡ For the title (as above) of this pamphlet, which I have not been able to consult, I am indebted to J. RUSSELL SMITH's *Bibliotheca Cantiana*, 1837. This landslip (and that of 1756) is mentioned by HASTED, Hist. of Kent, vol. i., p. 388, and in the *Gentleman's Magazine*, vol. xxvi., p. 1756.

"caused by the sliding some parts of it into the grounds below, either by its own weight, or some earthquake; . . . . . the bare place from whence this earth is slid, I have seen as far as Lewes, thirty miles from it."*

The face of the Upper Greensand escarpment in Hampshire has slipped in many places, forming the steep-sided, thickly-wooded hills called "hangers." MR. BRISTOW in his account of the Upper Greensand of that district, thus speaks of the hanger at Milkwell Wood:—†

"An account of this remarkable landslip may be introduced here, as it will serve to illustrate subsidences of a similar kind and in similar strata of frequent occurrence in many places along the cretaceous escarpments; amongst others, on the sea-coast at Lyme Regis, in Dorsetshire, and along the entire extent of what is commonly called the Undercliff on the south side of the Isle of Wight.

"In each of these cases the causes that have produced the effects have been the same; the superincumbent strata having been undermined by the springs thrown out by the impermeable clay of the Gault on which they are based, and having been rendered besides more than usually heavy by the water with which they are saturated after extraordinarily heavy rain-falls, a point is attained when the cohesion of the rock-mass is overcome by its own weight. It consequently gives way; the impetus with which it falls causing it to slide forwards in the direction of least resistance, over the unctuous clay of the underlying formation, for greater or less distances, dependent upon the weight of the foundered mass and the nature of the surface of the ground it passes over.

"The effect produced by landslips of this kind is so well described by Gilbert White in his account of the great fall which took place at Hawkley,‡ as to render it worth giving in full, notwithstanding the erroneous opinion entertained by the writer of the ground having 'gone down in a perpendicular direction,'—which is sufficiently disproved by his description of the subsequent appearance of the surface."

"'When I was a boy, I used to read, with astonishment and implicit assent, accounts in Baker's *Chronicle* of walking hills and travelling mountains.

* * * * *

"'But, when I came to consider better, I began to suspect that, though our hills may never have journed far, yet that the ends of many of them have slipped and fallen away at distant periods, leaving the cliffs bare and abrupt. This seems to have been the case with Nore and Whetham Hills, and especially with

* AUBREY'S Nat. Hist. of Surrey, vol. i. The date of the 5 vols. is 1719, but the publication began in 1673. The letter is reprinted in EVELYN'S Miscellaneous Writings, p. 687, 1825.

† Mem. Geol. Survey, Sheet 12, p. 7.

‡ Natural History of Selborne, letter lxxxvii.

the ridge between Harteley Park and Ward-le-ham [Worldham], where the ground has slid into vast swellings and furrows, and lies still in such romantic confusion as cannot be accounted for from any other cause. A strange event, that happened not long since, justifies our suspicions; which, though it befell not within the limits of this parish, yet as it was within the hundred of Selborne, and as the circumstances were singular, may fairly claim a place in a work of this nature.

"'The months of January and February, in the year 1774, were remarkable for great melting snows and vast gluts of rain, so that, by the end of the latter month, the land-springs, or levants, began to prevail, and to be near as high as in the memorable winter of 1764. The beginning of March also went on in the same tenor, when, in the night between the 8th and 9th of that month, a considerable part of the great woody hanger at Hawkley was torn from its place, and fell down, leaving a high freestone cliff naked and bare, and resembling the steep side of a chalk pit. It appears that this huge fragment, being, perhaps, sapped and undermined by waters, foundered, and was ingulfed, going down in a perpendicular direction; for a gate, which stood in the field on the top of the hill, after sinking with its posts for 30 or 40 feet, remained in so true and upright a position, as to open and shut with great exactness, just as in its first situation. Several oaks also are still standing, and in a state of vegetation, after taking the same desperate leap. That great part of this prodigious mass was absorbed in some gulf below, is plain also from the inclining ground at the bottom of the hill, which is free and unencumbered, but would have been buried in heaps of rubbish, had the fragment parted and fallen forward. About a hundred yards from the foot of this hanging coppice, stood a cottage by the side of a lane; and two hundred yards lower, on the other side of the lane, was a farmhouse, in which lived a labourer and his family; and just by, a stout new barn. The cottage was inhabited by an old woman and her son, and his wife. These people, in the evening, which was very dark and tempestuous, observed that the brick floors of their kitchens began to heave and part, and that the walls seemed to open, and the roofs to crack; but they all agree that no tremor of the ground, indicating an earthquake, was ever felt, only that the wind continued to make a most tremendous roaring in the woods and hangers. The miserable inhabitants, not daring to go to bed, remained in the utmost solicitude and confusion, expecting every moment to be buried under the ruins of their shattered edifices. When daylight came, they were at leisure to contemplate the devastations of the night. They then found that a deep rift, or chasm, had opened under their houses, and torn them, as it were, in two, and that one end of the barn had suffered in a similar manner: that a pond near the cottage had undergone a strange reverse, becoming deep at the shallow end, and so *vice versâ*: that many large oaks were removed out of their pendicular, some thrown down, and some fallen into the heads of neighbouring trees; and that a gate was

thrust forward, with its hedge, full six feet, so as to require a new track to be made to it. From the foot of the cliff, the general course of the ground, which is pasture, inclines in a moderate descent for half a mile, and is interspersed with some hillocks, which were rifted in every direction, as well towards the great woody hanger as from it. In the first pasture the deep clefts began, and running across the lane and under the buildings, made such vast shelves that the road was impassable for some time; and so over to an arable field on the other side, which was strangely torn and disordered. The second pasture field, being more soft and springy, was protruded forward without many fissures in the turf, which was raised in long ridges resembling graves, lying at right angles to the motion. At the bottom of this enclosure, the soil and turf rose many feet against the bodies of some oaks that obstructed their farther course, and terminated this awful commotion.

"'The perpendicular height of the precipice, in general, is twenty-three yards; the length of the lapse or slip, as seen from the fields below, one hundred and eighty-one: and a partial fall, concealed in the coppice, extends seventy yards more: so that the total length of this fragment that fell was two hundred and fifty-one yards. About fifty acres of land suffered from this violent convulsion; two houses were entirely destroyed; one end of a new barn was left in ruins, the walls being cracked through the very stones that composed them; a hanging coppice was changed to a naked rock; and some grass grounds and an arable field so broken and rifted by the chasms, as to be rendered, for a time, neither fit for the plough nor safe for pasturage, till considerable labour and expense had been bestowed in levelling the surface, and filling in the gaping fissures.'"

Earthquakes.—There is no necessity to give here any account of the earthquakes which have been felt in the Weald, as their effects have rarely been confined to this district. Such as desire that information can obtain it from the British Association Catalogue. There are, however, two accounts on record which are worth repeating here. The first relates to the great Lisbon earthquake as felt at Tenterden, and illustrates the effect which earthquakes are known to have on springs.* HASTED says:—†"On Saturday, Nov. 1st, 1755, between the hours of 10 and 11 in the forenoon, ... several ponds in this parish and neighbourhood, without any sensible motion of the earth, were greatly agitated, the waters of them being forced up the banks with great violence, fretting and foaming with a noise like the coming in of the tide, so as to terrify many who where near them; some of these waters flowed up three times in this manner, others circled round in eddies, absorbing leaves, sticks, &c., and it was observed that only those ponds were affected that had springs to supply the waters of them."

* In the *Phil. Trans.*, vol. xlix., p. 351 *et seq.*, is given an account of similar disturbances of ponds, &c., at the same time, at Cranbrook, Edenbridge, Godalming, and Midhurst.

† Hist. of Kent, vol. iii., p. 99, 1778.

CAPT. W. NOBLE, of Forest Lodge, Maresfield, describes an earthquake which took place in the neighbourhood of Uckfield, in the following words:*—

"The earthquake which visited the county of Sussex on the night of the 30th of April, 1864, was chiefly remarkable for the very limited area which it involved, considering the depth at which the disturbing force must probably have operated. From the most trustworthy information I can obtain, it would appear that taking Maresfield as the extreme north point, Lewes as the most southerly one, and Framfield and Hayward's Heath respectively as the most easterly and westerly points at which the shock was felt, a space of something like one hundred square miles would represent the extent over which the disturbing force was perceptible." After giving in detail the observations at various parts, CAPT. NOBLE says:—"Reference to the map of the Geological Survey will show that, with the exception of my own house, which stands upon a small patch of Wadhurst clay, and the town of Lewes, which, as is well known, is built upon the Chalk, every one of the places from which I have received information of the shock having been felt is situated upon the Tunbridge Wells sand, and even in my own case, the site of my house is close to a fault, and is surrounded by the Tunbridge Wells sand on all sides.

"It would seem therefore, that an earthquake wave must have passed through this stratum on the night of the 30th of April, in a W.N.W. and E.S.E. direction [*from* W.N.E. to E.S.E.,] and that it must have commenced and terminated, as far as can be ascertained, within a limit of ten miles in the direction of its length, and perhaps about the same in a lateral direction. Whence the origin of a shock so purely local, and so practically confined to a single stratum, is, I think, a curious problem for solution."

* *Proc. Geol. Assoc.* in *Geol. and Nat. Hist. Rep.*, vol. i., p. 21.

CHAPTER XVIII.—ORIGIN OF THE WEALDEN BEDS.

I propose in this Chapter to deal briefly with some points of great theoretical interest connected with the stratigraphical geology of the Wealden Beds, but which could not well be discussed until the lithological details were before us. I shall, for the most part, be content with making quotations from preceding writers which may illustrate the subject.

It seems at first sight strange that after the Wealden rocks have been so long and so carefully studied, we should still be in any doubt as to their mode of formation. Yet we find that some geologists speak of them as certainly lacustrine, others as estuarine, or as having been formed in the delta of a great river; whilst others speak of them indifferently under either head. This however, is a point which is not at all easy to settle.

In considering this question we must take the whole of the beds from the top of the Portland to the base of the Neocomian (as developed in the south of England) as one great series, intercalated between the higher Jurassic and the higher Neocomian strata. It is true that the Purbeck Beds are generally classed with the Oolites and the Wealden with the Cretaceous; but this has been done, following the views of PROF. E. FORBES, because in the Purbeck strata we find marine fossils of strong Oolite affinities (*Hemicidaris Purbeckensis*, &c.) Such are absent from the Wealden Beds; and when, in the highest strata, marine forms reappear, they are no longer Oolitic, but Neocomian.

If we must refer all existing strata to one system of classification, founded upon the marine deposits—and if only one system be allowed these must, of course, be taken as the standard,—we shall be obliged to class the Purbecks with the Oolites, and the Wealden with the Neocomian, having only an uncertain boundary between the two. But if, with PROF. HUXLEY, we allow terrestrial and freshwater strata a classification of their own, not necessarily strictly coincident with that of marine strata, then the Purbeck and Wealden will go together as one unbroken series; and such in fact they are.*

The Wealden Beds have been classed with the Cretaceous series, partly because of the Cretaceous character of the marine fossils with which the *highest* Wealden strata are associated, and also because they are strictly conformable to the true Cretaceous Beds, when overlain by them. But it must be remembered

* "At present our knowledge of the terrestrial faunæ of past epochs is so slight, that no practical difficulty arises from using, as we do, sea-reckoning for land-time; but I think it highly probable that, sooner or later, the inhabitants of the land will be found to have a history of their own,—mixed up with that of the sea, indeed, but independent of it, in some such relation as the histories of England and that of France."—PROF. HUXLEY "On Hyperodapedon," *Quart. Journ. Geol. Soc.*, vol. XXV. p. 150, 1869.

that, so far as we can judge by the Wealden fossils themselves, they are more nearly allied to the Oolitic than to the Cretaceous series. PROF. AGASSIZ long ago showed this as regards the Wealden Fish; and PROF. OWEN has done the same as regards the Wealden Reptilia. In the case of the Reptilia, however, it should be borne in mind that some of the fossils, reputed to be Wealden, are derived from conglomerates and bone-beds in which the bones and teeth are often more or less rolled; and it is not unlikely that in some cases these are really Oolitic fossils carried down by the Wealden river, which we know—from the presence of a rolled fragment of an Ammonite in the conglomerate at Lindfield, as well as from the fragments of Portland rock in like conglomerates—flowed over, and carried fragments of, secondary strata.

Regarding then the Purbeck and Wealden as one series of beds, we must seek for some cause which will explain the whole. We find that the major part of the strata are purely freshwater, but that at various horizons in the Purbecks there are bands of marine fossils. The Wealden Beds, until we come quite to the top, are wholly freshwater.

The total thickness of the Purbeck Beds in Durlston Bay is 370 feet. To the west of this they thin out; how much thicker they may be to the east, under the Isle of Wight, we do not know. The Wealden Beds at Swanage Bay are 2,500 or 3,000 feet thick. Taking the lowest estimate we obtain a total for the Purbeck-Wealden series of 2,870 feet at the east end of the Isle of Purbeck. At the western end of the Hastings Beds area in the Weald we may estimate the Hastings Beds at about 1,000 feet. We should allow a similar thickness for the Weald Clay, and perhaps about 400 feet for the Purbecks; making a total of 2,400 feet. Here, again, in the Weald, as to the west, the Purbecks give evidence of alternations of marine and freshwater conditions, whilst the Wealden Beds above are wholly freshwater.

We have, then, in the cases where we can fairly estimate the thicknesses, 300 or 400 feet of inferior strata, mainly freshwater, but containing some marine bands; and 2,000 or 2,500 feet of higher strata, which are freshwater only.

The Purbecks give evidence of somewhat deeper and quieter waters than do most of the Wealden strata. The beds of Paludina limestone (Purbeck marble) indicate this; and such are not found extensively developed in the Wealden Beds until we reach the upper portion, the Weald Clay. The REV. O. FISHER, in noticing that the large Saurian bones, which are so characteristic of the Wealden Beds, are absent from the Purbecks, suggests that perhaps the quieter waters of the Purbeck period could not bring them down.*

* On the Purbeck Strata of Dorsetshire. *Camb. Phil. Trans.*, vol. ix. p. 556, 1856.

Associated with the Purbeck Beds, both in Sussex and Dorset, are beds of gypsum and gypseous marls; these do not occur in the Wealden Beds.

The Ripple-marks, which so frequently occur in the Wealden Beds, are evidence of shallow water, not of an actual shore-line; but the footprints, which occur on several horizons, often associated with sun-cracks, must be taken as evidence of occasional dry surfaces.

There is one point of interest concerning the succession of the Wealden Beds, which though common enough in other formations, is especially characteristic of the Weald, that is, the suddenness with which the lithological characters of the rocks change. We frequently, in fact generally, find coarse conglomerates immediately capped by finely laminated clay or shale. Sometimes the conglomerate appears to have been, to a small extent, eroded before the deposition of the clay; for the latter lies upon an uneven surface of the conglomerate, which seems to have been worn smooth, and encrusted with ferruginous sand. There seems to have been a sudden pause in the deposition of the beds, the newer sediment being of a very different character from that which preceded it. It should be remarked, too, that the coarsest sediment—the conglomerate—lies at the top of the sand, immediately underneath the clay. The mass of the sand is generally fine-grained, but near the top it is coarser, and gradually becomes a conglomerate; this suddenly ceases and fine clay rests directly upon it. This occurs at several horizons in the Hastings Beds, and over very wide areas on each horizon.

It is not easy to account for such changes, although it would appear from borings through recent delta deposits, that something similar takes place now.

Another point of some interest is the suddenness with which palæontological changes take place. We find, in the Purbecks, that over a wide area there seems to have been sudden influxes of salt water, bringing in marine forms of life which, without any very great changes in lithological condition, were laid down upon the preceding purely freshwater bed. In the section already described at Limekiln Wood (p. 42) there is evidence of an intermingling of forms, for there a bed, which is mainly composed of *Cyrena*, also contains *Ostræa* and *Mytilus*.

To summarise the main facts to be explained:—we find, resting upon (and in direct sequence with) purely marine strata (Portland) a set of strata which are mainly freshwater, but which occasionally contain marine bands (Purbeck Beds); in these we find gypsum. The lithology and palæontology of these beds lead us to infer that they were mostly deposited in quiet and moderately deep water. These pass gradually up into strata which are wholly freshwater, the characters of which are:—alternating beds of sand and clay, the former generally exceedingly fine in grain, but sometimes—especially where immediately underlying the clays—much coarser, and often a coarse conglomerate. The sandstones sometimes exhibit ripple-marks and foot-prints. At the top of this series there are

again marine bands (Punfield Beds), the whole being surmounted, in direct sequence, by the truly marine Neocomian strata.

Whatever may have been the origin of this set of beds—whether they were formed in a lake, a delta, or an estuary—all geologists are agreed that they were formed in close proximity to the ocean, so that the salt water could obtain access to the area without great changes of level.

MR. S. V. WOOD, JUNR., has remarked that "the several phenomena which the character and grouping of the Wealden formation of England presents, demand the concession of geographical conditions at once peculiar, and not to be paralleled by any known existing lake or river, in order that such phenomena may not conflict with each other."*

This is true, whatever view we may take of the origin of the Wealden and Purbeck Beds. If they were formed in a lake it is not easy to account for the foot-prints or the gypsum, nor for the numerous intercalations of marine forms.

What we know of modern deltas helps to explain many things which are not easily accounted for by the lake theory. Gypsum may have been formed in small lakes or lagoons on the surface of the delta; foot-prints may indicate a surface of sediment left bare by the ebbing tide;† and the occasional invasions of the area by salt water, which would at times occur, account for the marine bands.

If we had only the Purbecks or similar beds to account for, this explanation might perhaps suffice; but I am not aware of any modern delta which exhibits any great thickness of purely freshwater strata. So far they have been carefully described they always contain salt or brackish water fossils. Lakes on the surface of the delta, when containing only fresh water, will give rise to freshwater deposits which may afterwards be covered up by and included in the ordinary sediment of the delta. But in such cases it would seem that we should have a great mass of estuarine or marine beds with only occasional bands of freshwater strata, just the reverse of what has occurred even in the Purbecks. For the Wealden Beds themselves, containing for 2,000 feet, as far as we know, not a single marine or estuarine fossil, I know of n modern example.

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* "On the Events which Produced and Terminated the Purbeck and Wealden "Deposits of England and France."—*Phil. Mag.*, Ser. 4, Vol. xxv. p. 268, 1863. In this paper the author contends that the Purbeck and Wealden beds were formed in a lake. The same view is taken by MR. GODWIN-AUSTEN (*see* especially his address to the Geological Section of the British Assoc. at Brighton, 1872). MR. C. J. A. MEYER has very well stated the arguments in favour of this opinion in his paper "On the Wealden as a Fluvio-lacustrine Formation....." *Quart. Journ. Geol. Soc.*, vol. xxviii. p. 243, 1872.

† It is probable that the range of tide would be small, for modern deltas are apt to occur in *tideless* seas, or in seas where the tides are of small extent. It is probable, that the scour of water at ebb-tide, where the range of tide is great, would effectually prevent the formation of a delta. *See* SIR H. DE LA BECHE'S, *Geological Observer*, 2nd ed., Chap. v., 1853.

It may perhaps be useful to collect here some extracts from published accounts of modern deltas, so far as these accounts illustrate the subject in hand.

The delta of the Mississippi, which extends over an area of about 12,300 square miles, was bored into at New Orleans in 1854 to a depth of 630 feet without reaching the bottom of the delta deposits. This boring passed through a succession of clays and sands, with some bands of pebbles in the higher part. The thickest bed of sand was that reached at 332 feet; this was 145 feet thick, and contained a little clay in the lower part, it is the sand which yields the water for which the boring was made.

SIR CHAS. LYELL, from whose account of the delta the foregoing notes are taken,* states that "General Humphreys has had the kindness at my request to submit the shells which were brought up from various depths to Professor Hilgard, author of a valuable report on the geology of the State of Mississippi, and he informs me that in one stratum occurring at the depth of 41 feet in the artesian boring, and which was composed exclusively of shells, he has found 22 species of Mollusca in a determinable state. All of them are of species now living in the gulf, and of which with one or two exceptions he has himself collected specimens on the shores of Ship Island near the mainland. They all belong to saltwater genera such as Mactra, Arca, Cardium, Lucina, Venus, Pandora, Astarte, Donax, Tellina, Oliva, Marginella, Buccinum, Natica, &c. Recent marine shells occurred at intervals as far down as 235 feet, but among the species obtained at that depth were a Tellina and Cardium which Mr. Hilgard has not yet been able to name; he remarks, however, that they do not agree with any of the American Miocene or Eocene species known to him. From much greater depths and near the bottom of the boring shells of living species were again identified, and among them *Venus Paphia*, *Arca transversa*, *A. ponderosa*, and *Gnathodon cuneatus*, the latter bivalve being one which swarms in the lagoons of the delta, such as Lake Pontchartrain, in such numbers that the dead shells are used for making roads."

SIR CHAS. LYELL considers it probable, judging from the depth of the gulf, that in the boring of 600 feet only a small part of the modern deposit has been pierced; that, in fact, the delta may be twice or thrice that thickness. He then adds:—"We must be prepared to find that the great bulk of it will contain marine and not fluviatile shells, and that a large part of the whole will consist of fine clay, although here and there pebbles and sand brought down to the bar will have been spread out during storms over wide areas."

"In boring vertically through any part of the delta, we may expect to pass occasionally through brackish-water strata, formed in lagoons, and through others containing purely marine shells; and if there have been oscillations in the level of the ground, as

* Principles of Geology, 10th ed., vol. i., p. 459, 1867.

may well be supposed in the case of tens of thousands of years, there will be alternations of fluviatile beds and freshwater cypress-swamps, with clays and sands containing marine shells."

Above New Orleans there are extensive deposits of gravel, sand, and loam, which are exposed to a thickness, in some cases, of 200 feet in the river banks. The shells here are wholly freshwater or land forms. This deposit is probably, as SIR CHAS. LYELL supposes, analogous to the loess of the Rhine, and the brick-earth deposits of our rivers, formed by floods.

The "pine-raft" of the Wealden Beds in the Isle of Wight, finds excellent modern representatives in the enormous rafts which are now carried down by the Mississippi.

The delta of the Po has been well explored by boring, particularly near Venice. MR. A. TYLOR has recently published a detailed account of these borings from the notes of MM. DEGOUSÉE and LAURENT.* The deepest boring is 572 feet. "The first beds contain shells generally all of marine species, together with fragments of human industry. The lower beds contain fluviatile shells, intermixed more and more with marine shells. The sands preponderate towards the inferior part and are frequently mixed with fragments of lignite disseminated through their mass. In the middle and upper parts these lignites occur in thin bands, and in beds alternating with clays or sands. Mica, very abundant in the lower part, is less so at the commencement [top] of the deposit. One may say that the beds of this deposit are almost horizontal throughout the area which we have explored."

LIEUT. R. B. SMITH† has published an account of a boring in the delta of the Ganges at Fort William, which in many respects well illustrates the succession of the Wealden Beds. The boring was carried down 480 feet, and passed through alternations of ferruginous sands, conglomerates, clays, marls and peat. At 150 feet from the surface there was clay, which at 175 feet gave place to a "coarse friable conglomerate" getting finer below. Still lower down on two different horizons, there were beds of conglomerate with bones of lizards and turtles. At 380 feet there were two feet of shells in blue calcareous clay, the species are not given, but the clay is described in "lacustrine." The lowest conglomerate was pierced to a depth of 80 feet, but the bottom of the delta deposits was not reached.‡

It is worthy of note that in this section we find a conglomerate immediately underlying clay, the beds below the conglomerate getting gradually finer. The same thing occurs at several horizons in the Wealden Beds. In some of the Wealden con-

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* *Geol. Mag.*, vol. ix., p. 485, plate xi. 1872.

† *Proc. Geol. Soc.*, vol. iv. p. 4, 1843.

‡ It is probable that the thickness of the Gangetic Delta deposits is very great; at least equal to the depth of the "swatch of no-ground." This is probably an area which has been kept free from alluvial sediment.

glomerates, as near Battle and in the Tilgate district, rolled bones and scutes of saurians and turtles are very common.

Dr. J. Hooker* has the following interesting remarks upon the surface features of the delta. The Jheels are sheets of still and clear water along or near the borders of the rivers; the Sunderbunds are near the sea:—

"To the geologist the Jheels and Sunderbunds are a most instructive region, as whatever may be the mean elevation of their waters, a permanent depression of ten to fifteen feet would submerge an immense tract, which the Ganges, Burrampooter and Soormah would soon cover with beds of silt and sand. There would be extremely few shells in the beds thus formed, the southern and northern divisions of which would present two very different floras and faunas, and would in all probability be referred by future geologists to widely different epochs. To the north [in the Jheels] beds of peat would be formed by grasses, and in other parts temperate and tropical forms of plants and animals would be preserved in such equally balanced proportions as to confound the palæontologist; with the bones of the long-snouted alligator, Gangetic porpoise, Indian cow, buffalo, rhinocerous, elephant, tiger, deer, boar, and a host of other animals, he would meet with acorns of several species of oak, pine cones and magnolia fruits, rose seeds, and Cycas-nuts, with palm-nuts, screw-pines, and other tropical productions. On the other hand, the Sunderbunds portion, though containing the bones of the tiger, deer, and buffalo, would have none of the Indian cow, rhinoceros or elephant; there would be different species of porpoise, alligator, and deer, and none of the above-mentioned plants, which would be replaced by numerous others, all distinct from those of the Jheels, and many of them indicative of the influence of salt water, whose proximity (from the rarity of sea shells) might not other wise be suspected."

Mr. J. W. Judd read before the British Association in 1870, an interesting paper on the "Age of the Wealden," in which he upholds the estuarine origin of the Wealden Beds. The author has kindly obliged me with the MS. of his paper, which has only been published in abstract, and from it I take the following extracts:—

"The Purbeck series which is found in the most northern part of the Wealden area, in the counties of Wiltshire and Buckinghamshire (where perhaps the higher portions of the series are wholly unrepresented), appears to be on the point of thinning out and disappearing when we come to the Bas Boulonnais, and is elsewhere unknown in France. In the interesting inlier of the Pays de Bray, which is so well described in the valuable work of M. Graves, the Wealden series is greatly reduced in thickness. We find, below beds representing our Gault and 'Lower Greensand,' a series of strata with all the mineral characters and fossils

* Himalayan Journals, vol. ii. p. 265, ed. 1863.

of the Wealden, which contains a number of intercalated marine beds, the lower of which contains a fauna which is undoubtedly that of the *Lower* Neocomian. According to M. HÉBERT and other accurate observers, the Wealden of France not only appears to have no connection with the Portlandian, but actually rests unconformably upon it. I think therefore that it is clear that the Wealden of France represents only the Upper or Neocomian portion of our Wealden.

"This view is confirmed when we come into the district of Champagne, for here the alternations of Wealden and Neocomian deposits is carried to a still greater extent. Under beds which unmistakeably represent our Gault and 'Lower Greensand' are seen red and mottled clays and sands with ironstones, containing a number of common Wealden fossils. Below these again occur a great series of limestones and clays, which have long been recognized as the undoubted representatives of the typical Lower Neocomian of Switzerland. Still lower occurs another freshwater series of sands and sandstones, the whole resting unconformably upon the Upper Oolites."

MR. JUDD then remarks upon the Wealden Beds of North Germany which he considers to have commenced at the close of the Oolitic period, and to have terminated before the close of the Lower Neocomian; it cannot therefore be regarded as strictly contemporaneous with that of England, the two areas are totally unconnected, and the deposits are probably the products of two different rivers.

PART IV.

ECONOMIC GEOLOGY.

CHAPTER XIX.—IRONWORKS.

Frequent mention has been made in the foregoing pages of the occurrence of ironstone at different places within the Weald, and also of its having formerly been smelted to a large extent. In this chapter I propose to give, 1st, a short sketch of the history of the trade, for the materials of which I am in great part indebted to MR. M. A. LOWER'S papers in the Sussex Archæological Collections;* 2nd, such knowledge as we possess, or may infer, as to the metallurgical processes adopted.

Of the origin of the ironworks in the south-east of England we have no certain knowledge. It is known that the Romans extracted iron at Maresfield, Framfield, Sedlescombe, Westfield, and Chiddingly, in Sussex, and probably also at Cowden in Kent. At Old Land Farm, near Maresfield, Roman pottery, coins, &c. were discovered amongst iron slags ("cinders") by the REV. E. TURNER in 1844. Human remains, probably of Roman interment, were found buried in the cinders. "If these were Roman interments, which can scarcely be questioned, we are led to suppose that they were made long subsequently to the original deposit of Scoriæ, since a *recently-formed* cinder-bed would have been a very unlikely spot to be selected for the burial of the dead. The fair inference from these considerations is, that the ironworks at this place were carried on by the Romans during a long series of years."†

It is possible that the works in some places were started by the Celts. MR. W. BOYD DAWKINS in 1862 ‡ found rough unturned pottery, with flint flakes, *on the surface* of a slag heap, north of Bathurst Wood, near Battle. Although such pottery and flakes have been found associated with true Roman remains, yet, according to MR. DAWKINS, nothing of undoubted Roman age has been found here. This fact, together with the express mention

* Vol. ii. p. 169, 1849; Vol. iii. p. 240, 1850; Vol. xviii. p. 10, 1866. The first of these papers was reprinted in Mr. LOWER'S Contributions to Literature, Historical, Antiquarian, and Metrical, p. 85, 8vo., Lond. 1854. Subsequent references will be to this reprint, unless otherwise stated. For many authorities, quoted or referred to in the following paper, I am indebted to Mr. LOWER'S exhaustive essays; but, with very few exceptions, I have taken the quotations direct from the original sources.

† LOWER, p. 89. A remark of STUKELEY'S is worth quoting here:—"'Tis said that hereabouts [Saltwood Castle] anchors are dug up, which, if true, is not owing to the sea's coming so high, as the vulgar think, for that's impossible; but to an iron forge of the *romans* conveniently placed, where so much wood grows, so near the sea and so many ports." Itinerarium Curiosum, p. 124, 1724.

‡ *Trans. International Congress of Prehistoric Archæology*, 3rd Session, p. 185, 1868.

by CÆSAR of the occurrence of iron in the maritime regions of Britain, is regarded by MR. DAWKINS as affording a probability of the pre-Roman age of the works.

We have, at present, no means of knowing whether the ironworks were continued in this district after the departure of the Romans. It is very unlikely that so important a manufacture would cease; but it is remarkable that Domesday Book, which enumerates ironworks in various counties of England, should make no mention of those in Sussex.*

The earliest known document relating to the iron trade of Sussex is dated 1266. It is a grant of HENRY III. to the town of Lewes empowering them to levy toll for the repair of the town wall. "Every cart laden with iron from the neighbouring Weald, for sale, paid one penny toll, and every horse load of iron, half that sum."† From this time downwards there are frequent mentions of the iron trade.

The earliest account yet known of the *extent* of the works, is contained in a return, ordered in 1574, of all owners of ironworks in Kent, Surrey, and Sussex. It is preserved in the State Paper Office. A list relating to Sussex is given by MR. LOWER.‡ This enumerates 38 forges and 32 furnaces; but besides these there were "dyvers fordgs and furnaces" in several other places, which would considerably add to the number.

JOHN NORDEN in his "Surveyor's Dialogue," published in 1607, says (p. 215):—"I have heard there are or lately were in Sussex neere 140 hammers and furnaces for iron,§ and in it and Surry adjoyning, 3 or 4 glasse houses."

We learn from STURTEVANT ‖ that there were in 1612, in Great Britain and Ireland, "eight hundred milnes for the making of iron," of which there were "foure hundred milnes in Surry, Kent, and Sussex, as the townsmen of Haslemore haue testified and numbred unto me." DUD DUDLEY refers to this estimate and supposes that of the "eight hundred milnes," 500 were forges and 300 furnaces,¶ which would give for Surrey, Kent, and Sussex about 250 forges and 150 furnaces. Probably these numbers are greatly exaggerated. From a document lately preserved at Horsham and printed by LOWER,** we learn that there

* In Somerset, Hereford, Gloucester, Cheshire, and Lincoln (*see* LOWER, Contrib. to Lit., p. 95). It appears doubtful if Domesday Book can be depended upon for accurate accounts of Metallurgy and Mining in Norman times (*see* HULL, Coal Fields of Great Britain, 2nd ed., p. 18, 1861). Such subjects appear to have been only mentioned incidentally. But it is strange that the quantity of wood, the mills and fishponds, should be carefully enumerated, and this subject for the most part omitted.

† LOWER, Contrib. to Lit., p. 96.

‡ *Sussex Arch. Coll.*, vol. iii. p. 240.

§ Upon this statement LOWER has the following note:—"It is a somewhat singular coincidence that the number of corn mills in Sussex, at the time of the Domesday Survey (finished in 1086), was 148; and that of iron mills, about five centuries later, 140. A great proportion of the latter probably occupied the sites of the former, which the introduction of windmills had caused to be deserted." p. 119. In many places water-mills now occupy the sites of old ironworks.

‖ "Metallica." 4to, 1612, p. 5. Reprinted at Wolverhampton, 1855.

¶ "Metallum Martis," 4to, 1665, p. 48.

** *Sussex Arch. Coll.*, vol. xviii. p. 15.

were in Sussex in 1653, 27 furnaces and 42 forges, many of which were discontinued before 1664.

In BUGDEN'S Map of Sussex, published in 1724, there are marked 12 furnaces and 7 forges. These are also shown on a small map by BOWEN, published about 1745, which is founded on BUGDEN'S. A second edition of BUGDEN'S map was published in 1779, in which all the ironworks shown in the first edition are retained, but this we know to be incorrect. BUDGEN'S map is exceedingly curious, the title being ornamented with various drawings emblematic of the iron trade.

In 1740 there were four furnaces in Kent and 10 in Sussex. In 1788 there were two in Sussex and none in Kent;* in 1796 only one remained in Sussex (Ashburnham furnace), which lasted till 1828, when this, the last of the Sussex furnaces, was finally given up.

Iron articles of Wealden manufacture are very common in the district. Chimney-backs and brandirons or andirons are especially abundant. Iron "tombstones" still remain in the churchyards, and it is said that at Wadhurst alone there are thirty of them. The iron railings now round St. Paul's were made at Lamberhurst, on the border of Kent.†

The earliest known example of Sussex ironwork is a monumental slab in Burwash Church. It is of the 14th century, and is said to be of *cast-iron*;‡ if so, it is also the earliest known example of this.

Cannon were important articles of manufacture. How early wrought-iron guns were made here (or, indeed, elsewhere) is uncertain, but we know that in 1543 cannon were *cast* at Buxted. HOLINSHED, in his Chronicle, says: — "This yeare the first cast pieces of iron that ever were made in England, were made at Bucksteed, in Sussex, by Rafe Hoge, and Peter Bawd." This statement refers to Ordnance.

A gun, probably of Wealden manufacture, is preserved in the Rotunda Museum at Woolwich, for which an earlier date is claimed than that given by HOLINSHED. It is thus described in the Official Catalogue:—§ "Wrought-iron 15 in. bombard, for throwing stone shot of about 160 lbs. weight; calibre 15·1 inches; interior diameter of chamber 3·4 in.; length of chamber 14·0 in. capacity of chamber about 3·5 lbs.; length of chase 34·0 in.; present weight 6 cwt.

"This very curious piece of ordnance is said to have been found in the moat of Bodiham Castle, and was preserved for many years at Battle Abbey. It is at least as old as the earlier part of the 15th century. The interior is of *cast-iron*, and probably one of the earliest known specimens of iron in that form."

* Encyclopædia Britannica. 8th Ed., 1856. Article, "Iron" (by SIR W. FAIRBAIRN).

† HASTED, proud of his county's productions, says of these railings:—"They compose the most magnificent balustrade, perhaps, in the Universe." *Hist. of Kent*, vol. ii. p. 382. These railings were partly removed in January 1874.

‡ LOWER, Contrib. to Literature, p. 97.

§ Ed. 1864, by BRIG.-GEN. J. H. LEFROY, p. 1.

This gun is probably not much older than the date here mentioned, for Bodyham Castle was built in 1386, and it is unlikely that old ordnance would be mounted on it.

There was formerly a gun standing at Eridge Green, reputed to be the first mortar that was made in England.* There is now at Holtye, near Cowden, a cannon 7½ feet long.

Ordnance continued to be cast in the Weald till quite late times. LOWER says (writing in 1848), cannon were cast at Worth, and sent to London within the last 70 years. Of Hastings, in 1797, it was said:—"A great deal of plank, iron, and grain, are brought here from the country, to be exported coastwise, though this branch (which consisted chiefly of cannon from the founderies at Robertsbridge and Ashburnham), has failed considerably within these few years, owing to the great scarcity of wood for heating the furnaces; for since the hop planting is become so principal a branch of the farmer's system, the woods that are now remaining are chiefly reserved for hop poles."† DR. C. LE NEVE FOSTER, in 1861, met with an old man at Hawkhurst, who, when a boy, was in the habit of playing truant to see the guns tried at Gun Green.

Although the works were carried on into the present century, not a single example of furnace or forge is known to exist in the district. The most striking remains of the works are the large hammer-ponds, of which numbers still remain, and serve as mill-ponds.‡ But in many cases the dams have been cut through, and the ponds drained. There was a hammer-post standing in 1862 at Howbourne,§ near Buxted; and I was told of one which a few years before stood near Tickeridge Mill, N.E. of Framfield.

The old boards at the turnpike gates occasionally serve to remind us of the departed trade. At Paris Corner Gate, near Bethersden, and at the Gate near Kennardington Cross, there are notices as to the tolls on "mine, charcoal, sea coal, iron guns, or other iron." But the most enduring records of the iron trade are the local names, which will remain to tell their tale long after every other evidence has passed away. The words Furnace, Forge, Iron, Steel, Cinder, Hammer, Tongs, Gun, &c. are of common occurrence, especially over the Hastings Beds.

The decline of the iron trade was owing to the scarcity of fuel, not to the want of ore. The drain upon the woodland would necessarily be less in the earlier times, when iron was got direct from the ore in the malleable state, than when blast furnaces were introduced, and *cast* iron was first got, to be afterwards converted into malleable iron. As we have seen, the exact date of this change is unknown. The introduction of pit-coal in smelting

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* *See* the figure and description in *Archæologia*, vol. x., p. 472, Pl. xxxviii., 1792. The sketch was taken in 1768.

† *Hastings Guide* [by — BARRY], 2nd ed., p. 64.

‡ Of which NORDEN says, "I think these two shires [Sussex and Surrey] have more of them than any twenty other shires in England." *Surveyor's Dialogue*, p. 219.

§ This name is not engraved on the map. The farm is close to the junction of two streams, south-east of Grove Wood, and two miles above Buxted Bridge. The hammer-post is figured by LOWER, p. 132.

iron gave the final blow to the Wealden trade. Various trials had been made with this early in the 17th century, but it was not till about the year 1735 that ABRAHAM DARBY fully surmounted the difficulties connected with the process. It was just about this time that the Sussex iron trade rapidly declined.

The great drain upon the woodlands, which charcoal furnaces entailed, led to legislative action for their protection so early as 1543. This is the year given by HOLINSHED for casting the first cannon in England. Cast-iron was previously in use, how long before we do not know; but the development of the blast furnace, and the consequent increased consumption of wood, was doubtless the immediate cause of parliamentary interference. From the operation of this earliest act (35 HENRY VIII.) the Wealden woodlands were exempt, except the *common woods* of that district.

The act of 1 ELIZABETH likewise did not apply to "the county of Sussex, nor to the Weild of Kent, nor to anie the parishes of Charlewood, Newdigate, and Legh, in the Weild of the countie of Surrey."

The act of 23 ELIZABETH (1581) refers solely to the Wealden ironworks. It is entitled "An Act touching iron mills, neere unto the citie of London, and the river of Thames." It provides that no wood shall "be converted or emploied to coale or other fewell" for ironworks within 22 miles of the Thames, or within 4 miles of the Downs between Arundel and Pevensey, or within 4 miles of Winchelsea and Rye, 3 of Hastings, and 2 of Pevensey. The Weald within 18 miles of London or 8 of the Thames* was exempt. No new ironworks were to be erected within 22 miles of London, 14 miles of the Thames, nor within 4 miles of the before-mentioned towns. This Act excludes the woods of "Christopher Darrell gentleman, in the parish of Newdegate, within the weald of the countie of Surrie, which woods of the said Christopher have heeretofore beene, and be by him preserved and coppised for the use of his iron works in those parts."

The Act 27 ELIZABETH (1585)—"An Act for the preservation of timber in the wilds of the counties of Sussex Surrey and Kent, and for the amendment of the high waies, decaied by carriage to and from the iron mils there"—prohibits the erection of new ironworks, except upon old sites, or where the owner can supply fuel from his own woods. No one was allowed to fell for this purpose timber of "oke, ash, or elme, growing of the bredth or bignesse of one foot square at the stub." The tops and offal of all such trees in the Weald might be used, but not within 18 miles of London, 8 miles of the Thames, or near the towns mentioned in the preceding Act.†

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* This statement is curious. No part of the Chalk escarpment of the North Downs is within eight miles of the Thames, excepting a little near the Medway, about Snodland and Boxley. But the Lower Greensand area of Kent was not generally taken as part of the Weald (*see* p. 401).

† *See* p. 378, for a notice of this Act and that of 39 ELIZ., in connexion with the highways of the Weald.

Although writers of this period generally deplore the great waste of the woodlands, yet they by no means regard the "devouring ironworks" as unmixed evils. NORDEN says:*—"He that hath known the Welds of Sussex, Surrey, and Kent, the grand nursery of those kinds of trees, especially Oake and Beech,† shall find such an alteration within lesse than 30 yeres, as may well strike a feare, but few yeeres more as pestilent as the former will leave fewe good trees standing in those Welds." NORDEN, however, seems to think the destruction of wood rather a benefit to the Weald than otherwise, since it increased the area of arable and pasture land.

JOHN EVELYN, not less indignant than others at the threatened scarcity of wood, admits that the ironworks might be so ordered, as to be rather a means of conserving the woods. He cites,‡ in illustration of this, the case of CHRISTOPHER DARELL, gentleman, who, by the acts already quoted, "had a particular indulgence for the cutting of his Woods at pleasure, though a great Ironmaster; because he so ordered his Works, that they were a means of preserving his Woods; notwithstanding those insatiable devourers. This may appear a Paradox, but is to be made out; and I have heard my own Father (whose Estate was none of the least wooded in England) affirm, that a Forge, and some other Mills, to which he furnished much Fuel, were a means of maintaining and improving his Woods; I suppose, by increasing the Industry of planting, and care."

The ore most commonly used was the clay ironstone, which occurs in nodules and thin beds towards the bottom of the Wadhurst Clay. There is also a bed of shelly calcareous ironstone occurring a few feet above the Ashdown Sand, which would, of itself, serve for both ore and flux. It was probably extracted at the same time as the ironstone.

The ore was worked mainly by means of bell-pits, of about 6 feet in diameter at the top, and widening towards the bottom. They were generally shallow, rarely more than 20 feet deep; sometimes they were connected by levels. Great numbers of these pits ("mine-pits") still remain in the woods, generally they are full of water. On the pasture fields they have been partly filled up, and here the surface very much resembles that produced by "day-falls" near the crop of a worked-out coal-seam. Scarcely any traces of workings now remain over the arable lands. Waste-heaps do not occur over the worked ground; it is therefore probable that the shale was carted away as "marl," and perhaps was paid for as such. This is a point of some im-

* The *Surveyor's Dialogue*, p. 214, 1607.

† This is a mistake. Beech is plentiful on the Chalk, on the Upper Greensand of Hants, and occurs in places on the Lower Greensand; but it certainly is not a characteristic tree of the Wealden district proper.

‡ Sylva, a Discourse of Forest Trees; and the Propagation of Timber in His Majesties Dominions. Fol. 1664, p. 110. EVELYN lived at Wotton, and is buried in the church there. Much of the fine wood thereabouts, and near Leith Hill, is reputed to be of his planting.

portance in view of any proposed re-opening of these workings. There is now no demand for "marl," and the removal of a great quantity of waste material would be a serious item in the expenses of working. Large "marl-pits" are often found near the base of the Wadhurst Clay, and from these the ironstone would of course be removed. The chief method of working was by bell-pits; and I am not aware of any traces of "hushing" or "scouring," such as was formerly practised in South Wales. There is in other respects much similarity between the old workings of South Wales, the Forest of Dean, and the Weald. DR. PERCY prints an interesting "Account of making Cast or Pig Iron (wch are the same) in Great Britain, and more particularly in Monmouthshire and Breconshire."* The date is about 1750. The "scouring" is thus described:—"On the wash or enclosed ground on the sides of the Hills where we find Oar we digg a Trench about four or five foot wide till we come down to the Lowest Vein, about 14 foot deep, and in that Depth is usually 4 Veins or Layers of Oar. Then we make small ponds to hold rain water, or any that comes out of Springs above the Trench that is cut; and as fast as the Ponds fill we let them down through a Floodgate into the Trench, which carries away all the loose Earth, and leaves the myne behind and the lowest Vein bare. Then they undermine the Banks of the Trench on both sides, and when great quantities of the Banks are fallen down they let down the water out of the ponds again, which washes away all the Earth from the myne." It would be of some interest to examine the worked districts in the Weald to see if there be any evidence of such a method having been practised there.

The ore is here called "myne," and the word (written "mine") is still used in South Wales to denote argillaceous ironstone. It was, and still is, the usual term for the Wealden ironstone; sometimes the ore is called "mine-stone" and "iron-mine." These terms apply to the raw ore; but in the Pyrenees, where the Catalan process is used, the word "mine" denotes the larger pieces of calcined ore, after the whole has been burnt, crushed, and sifted.†

The local names in use for the various beds of ironstone, &c. at Ashburnham were first published by YOUNG,‡ and have been reprinted by later writers. DR. MANTELL, writing in 1822, when the furnace was still working, says:§—"The provincial terms employed by Mr. Young are now obsolete; at least I was unable to obtain any explanation of them from the workmen, on a recent visit to Ashburnham." This, as we shall presently see, was an error. YOUNG says:—"At the bottom of the Earl of Ashburnham's park, sandstone is found, solid enough for the purpose of masonry. Advancing up the hill, the sand-rock is 21 feet in thickness, but so friable, as

* Metallurgy.—Iron and steel, p. 897. The account is printed from a MS. in the possession of Mr. OCTAVIUS MORGAN.

† *Ibid.*, p. 294.

‡ *Agriculture of Sussex*, 8vo. ed., 1808, p. 14.

§ Fossils of the South Downs, p. 29.

easily to be reduced to powder [Rock sand at the top of the Ashdown Sand]. On this immediately a marl rests on [Wadhurst Clay], in the different depths of which the ironstone regularly comes on in all the various sorts, as follows:—

1. Small balls, provincially, *twelve-foots*, because so many feet distant from the first to the last bed.
2. Grey limestone; what is used as a flux.
3. Foxes.
4. Rigget.
5. Balls.
6. Cabella Balls.
7. White-burn.
8. Clouts.
9. Petty."

The EARL OF ASHBURNHAM communicated the following note to MR. C. GOULD; it is dated 14th February 1836:—*

"Enumeration of Strata in the Iron beds on the estates of the Earl of Ashburnham in Sussex.

"Provincial names of the beds from Thos. Hobday, many years employed upon the estate in drawing mine:—

No. 1. Twelve foots.
2. Greys. [Probably a limestone.]
3. Foxes.
4. Greys. [Probably a limestone.]
5. Hazards.
6. Bulls.
7. Cheveliers.
8. White bands.
10. Pitty.
11. Colours.

"These beds begin with No. 1 as the uppermost in the series, and always follow, in some of their numbers, the same order of succession, although in very few instances has Hobday seen the whole present. Sometimes the upper beds, sometimes the middle, and sometimes the lower series are only found."

The foregoing accounts agree tolerably well. No. 4 in the second is account not given in the first; the two last are evidently the same beds in each account, but the order is reversed.

A short notice of Lamberhurst furnace is given by HASTED. Here, too, the ore came from the bottom of the Wadhurst Clay:—

"The iron-ore is found in great abundance in most parts of these woods, but different in colour, weight, and goodness. That which is not so fit for common use, on account of its being short and brittle when melted, is mingled in due quantity with cinder, being the refuse of the ore after the metal has been extracted from it, which gives it that temper of toughness as makes it fit for use."†

* The words in brackets are inserted by MR. GOULD.
† *Hist. of Kent*, vol. ii. p. 382, 1782.

The following information about the modern workings in Ashdown Sand at Snape Wood, near Wadhurst, was collected by Dr. C. Le Neve Foster:—*

"The mine was commenced in August 1857 and abandoned in September 1858; the ore was sent into Staffordshire. The ironstone was worked on both sides of the railway, just west of the 53rd milestone, by levels and cross-cuts. On the north side of the railway only one bed was worked, this was 1 foot 9 in. thick, underlain by a hard sandstone. The roof is sometimes bad and required timbering. On the south side of the railway two beds were worked, only one of which could be examined, as the level contained much water; this bed was two feet thick. In this level the ground was softer and required more timber.

"The beds of ironstone were very irregular, but were found to be better on the south than on the north side; in both cases, however, the beds died out suddenly and re-appeared at intervals. Several shafts have been sunk from the higher ground.

"The ore, a clay-ironstone, was sometimes calcined on the spot. A great deal of raw ore still lies by the side of the railway."

The more ferruginous sandstones seem to have been worked over the sandy areas of the Hastings Beds.

Over the Weald Clay the ore would be clay ironstone where this could be got, but it is not known if it keeps to definite horizons in the clay.

In Surrey and West Sussex the concreted ferruginous gravel, called "Ragstone," which lies on the Weald Clay, has been used for smelting.†

We have no information as to what ores were got from the Lower Greensand. So far as I know there is no evidence of smelting having been carried on over the Lower Greensand of Kent or East Surrey. There seem to have been furnaces on this formation in West Surrey, and there certainly were some in Sussex. Perhaps the ore here would be the brown siliceous ironstone, or "Carstone," which occurs in the Folkestone Beds. This contains a rather high per-centage of iron (as hydrated sesquioxide), but it seems hardly suited for the purpose. The bright red ferruginous grit (anhydrous sesquioxide) which, through part of Sussex, occurs at the base of the Gault, would probably serve better; but this only occurs in a single band of two or three inches in thickness. The Sandgate Beds in West Sussex contain an iron-sand which might possibly serve as ore. Similar stuff is also found at the same horizon near Albury, in Surrey (*see* pp. 134 and 136).

In the sands which occur along the top of the Chalk escarpment in East Kent, there is a ferruginous grit very like the "Carstone" of the Folkestone Beds; and occasionally in the same beds there is ironstone, undistinguishable from that which occurs in the Lower Tertiary Beds at Boughton, near Canterbury. It is in this iron-

* *See* p. 72.

† Martin, Western Sussex, p. 41.

stone that the fossils found near Lenham occur. There is no proof that any of this was actually worked; but there is evidence to show that it was proposed to work it. ARCHBISHOP PARKER, writing to QUEEN ELIZABETH in 1570, says:—"Sir Richard Sackville intends, as I am credibly informed, in this wood [Longbeech Wood, in Westwell, Kent] to erect up certain iron mills, which plague, if it shall come into the country, I fear it will breed much grudge and desolation."*

Longbeech Wood is on the Chalk, just north-east of Charing. The country there is covered by clay-with-flints, and some "Crag" sand. There is nothing about here but the ironstone in the latter which could be used for ore. This statement is useful as proving the *absence* of ironworks in that district at that time.

MR. FURLEY† states that "in the year 689 Oswini of Kent grants to Rochester a ploughland at Lyminge in which he says 'there is known to be a mine of iron.' Mr. Kemble remarks that 'this document is not totally free from suspicion.'"

The parish of Lyminge is wholly on the Chalk, and although it is unlikely that the actual parish boundary was then settled as we now have it, yet it is very improbable that the charter refers to any of the country below the Chalk escarpment. The "mine of iron" can then only apply to the "Crag" sands. It should be noted here, however, that there are other charters which, by some authorities, are supposed to refer to Lyminge, but which are by others claimed for Lympne.‡ If this charter refer to Lympne the ore would probably be the clay-ironstone of the Weald Clay.

I know of no complete analyses of the Wealden ironstone. The clay-ironstone of the Wadhurst Clay at Ashburnham contains 35 per cent. of iron,§ which is about the average per-centage of Coal Measure clay-ironstone. The following note on the Wealden Ironstone has been published:‖—"The stone from which this iron was manufactured seems principally to have been a spathose ore, or an altered spathose ore, where the carbonate of iron has been converted into a hydrated peroxide. The per-centage of this class of ore seems to be very good, some which I tried producing as much as fifty per cent., a fair average would seem to range from twenty-five per cent. to forty per cent. Other classes of ores have also probably been used, for clay ironstone is often found, although so far as I personally observed, generally poor; and siliceous ores occur in other places. But the spathose ore is certainly the most valuable—

* Quoted by LOWER (p. 109) from STRYPE'S *Life of Archbishop Parker*, p. 315.

† *Hist. of Weald of Kent*, p. 208.

‡ *See under* Romney Marsh, p. 306.

§ According to an assay by MR. R. SMITH, of the Metallurgical Laboratory, Royal School of Mines.

‖ "The Sussex Ironstone, The Pick and Gad," No. 2, Dec. 1857. The "Spathose ore" referred to is probably the shelly limestone of the Wadhurst Clay. This is of a dark bluish or greyish colour when freshly dug and fractured, but is of a dark brown colour when found on the surface.

indeed, as far as I can judge, it seems the only stone existing in sufficiently compact bodies to be worked to profit."

Of the quality of the Wealden Iron there are conflicting accounts. CAMDEN says of Sussex:*—"The iron melted here, either from the natural quality or management of the metal, is not of the same goodness, and in general more brittle than the Spanish iron." FULLER, on the other hand, says, also of Sussex:†—It is almost incredible, how many [great guns] are made of the iron in this county. Count *Gondomer* well knew their goodness when of K. *James* he so often begg'd the boon to transport them." LOWER thus speaks of the Wealden iron:‡—"That *some* of the iron wrought here was of the first quality there can be no doubt. The Ashburnham iron, particularly, excelled in the quality of toughness, and I have been assured by smiths who have used it, that it was in no wise inferior to the Swedish metal, generally accounted the best in the world." In the Weald (as in Sweden), charcoal only was used. This gives a better quality of iron than coke.

Steel was made at Warbleton and Robertsbridge. Most of the charcoal used in the Wealden furnaces and fineries was made from *oak* wood. This is found in the Catalan furnaces to be more favourable to the production of steely iron than charcoal from lighter wood.

We are sadly destitute of information regarding the methods adopted for working the ore. In the earlier times the iron was got in a malleable state *direct* from the ore. DR. PERCY supposes that the process adopted closely resembled that known as the "Catalan process," which is still employed in the Pyrenees. In this process the slags produced are necessarily rich in iron, as are also the old slags and "cinders" in the Weald. This does not indicate an imperfect process of extraction, as is often assumed. "They did by one process, according to the *direct method*, what we now effect by two; and the slag which they produced should be compared not with our blast-furnace cinder, but especially with our finery, tap, and flue cinders."§

Possibly the following account of the process adopted in Lancashire in 1675 better represents that in use in the Weald in early times, than the more elaborate, though essentially similar, Catalan Process. The furnace is thus described:‖—"It is very much like a common blacksmith's, viz., a plain open hearth or bottom without any enclosing walls, only where the nose of the bellows come in through a wall there is a hollow place (which they call the furnace) made of iron plates, as is also that part of the hearth next adjoining. This hollow place they fill and upheap with charcoal, and lay the oar (broken small) all round

* GOUGH's ed., p. 185.
† Worthies of England, p. 99, fol. 1662.
‡ Contrib. to Lit., p. 121.
§ PERCY's Metallurgy.—Iron and Steel, p. 876, 1864. A full description of the Catalan Process is given in this work (pp. 278–315).
‖ Quoted by DR. PERCY (p. 598) from *Phil. Trans.*, vol. xvii. p. 695, 1693.

about the charcoal upon the flat hearth, to bake, as it were, or neal and thrust it in by little and little into the hollow, where it is melted by the blast. The glassie *Scoriæ* run very thin, but the metal is never in a perfect fusion, but settles as it were in a clod, that they take it out with tongs, and turn it under great hammers, which at the same time beat off (especially at first taking out of the furnace) a deal of coarser *Scoriæ*, and form it after several heats into bars. They use no limestone or other thing to promote the flux, for that I inquired particularly."

When cast-iron was first made in a blast furnace, is a matter of conjecture. We have seen that, in the Weald, cannon were *cast* in 1543, and possibly much earlier.

Of the character of the Wealden blast furnaces we are as ignorant as we are of the older and simpler forms. Possibly we may get some light on this matter from South Wales. In the reign of HENRY VIII. some ironmasters removed from Sussex to Glamorganshire, and there established ironworks. The remains of one of their furnaces are still preserved, and have been described and figured by MR. W. LLEWELLIN,* from whose pages I take the following extract. It is likely that the iron-masters would continue to work the ore much in the same manner as they had done in Sussex; of this, however, there is no proof, and I give the following account of a furnace, *probably* built on the Sussex plan, only because no better evidence is attainable.

The remains are situate in the valley of Cwm Aman.

"The furnace was built with sandstone, belonging to the Pennant series of the neighbourhood, which appears to have acted well for the purpose; it was lined with the same material, and neither fire-bricks nor the conglomerate usually designated as 'plum pudding stone' were employed. The extreme height of the furnace was about 16 feet to the *top of the chimney*, which itself must have been at least 2 feet high. The internal cavity from the top of the bosh to the head of the furnace is 8 feet high; its diameter at the top of the bosh was 5 feet; and the bosh itself was peculiar in form, being only 10 inches in height, and inclining to the top of the hearth at an angle of 45°, when it became diminished to a diameter of 4 feet 3 inches. The height of the hearth was unusually great in proportion to that of the bosh; it inclined on an angle of 77°, and was 5 feet 2 inches high, and diminished at the bottom to 2 feet. At its outer extremity, the tuyere opening was 3 feet in height and 2 feet wide, and was approached by an arch, extending from the outer wall of the furnace. The hearth and bosh were circular in form, but the latter was then gradually worked off into a square, and so extended upwards. The square of the outer walls of the furnace was about 24 feet."

We have a tolerably detailed account of the method adopted in the Weald of extracting cast-iron and from that malleable iron.

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* *Archæologia Cambrensis*, Ser. 3, vol. ix. p. 86.

This has been preserved by RAY, who says:—"This account of the whole process of the Ironworks I had from one of the chief Iron-masters in Sussex, my honoured friend *Walter Burrell*, of *Cuckfield*, Esquire, deceased."*

"*The manner of the Iron-work at the Furnace.*

"The Iron-mine lies sometimes deeper, sometimes shallower in the Earth from 4 foot to 40, and upward.

"There are several sorts of mine, some hard, some gentle, some rich, some coarser. The Iron-masters always mix different sorts of mine together, otherwise they will not melt to advantage.

"When the mine is brought in, they take small cole [charcoal] and lay a row of small cole and upon it a row of mine, and so alternately, S.S.S. one above another, and setting the coles on fire therewith burn the mine.

"The use of this burning is to mollifie it, that so it may be broke in small pieces; otherwise if it should be put into the furnace as it comes out of the Earth, it would not melt but come away whole.

"Care also must be taken that it be not too much burned, for then it will loop, *i.e.*, melt and run together in a mass. After it is burnt, they beat it into small pieces with an Iron sledge, and then put it into the Furnace (which is before charged with coles) casting it upon the top of the coles, where it melts and falls into the hearth in the space of about twelve hours more or less, and then it is run into a Sow.

"The hearth or bottome of the furnace is made of a Sand-stone, and the sides round to the height of a yard or thereabout, the rest of the Furnace is lined up to the top with Brick.

"When they begin upon a new Furnace; They put fire for a day or two before they begin to blow.

"They then blow gently and increase by degrees till they come to the height in ten weeks or more.

"Every six days they call a *Founday*, in which space they make 8 tun of Iron, if you divide the whole summ of Iron made by the *Foundays:* for at first they make less in a *Founday*, at last more.

"The hearth by the force of the fire continually blown grows wider and wider, so that if at first it contains so much as will make a Sow of 600 or 700 pound weight, at last it will contain so much as will make a *Sow* of 2,000*l.* The lesser pieces of 1,000 pounds or under they call *Pigs.*

"Of 24 loads of coals they extract 8 tun of Sows to every load of coals, which consists of 11 quarters, they put a load of mine which contains 18 bushels.

"A Hearth ordinarily if made of good stone will last 40 *Foundays*, that is 40 weeks, during which time the fire is never let go out. They never blow twice upon one hearth, though they go upon it not above five or six *Foundays.*

* A collection of English Words Not Generally used. . . . . And an Account of the preparing and refining such Metals and Minerals as are gotten in England. 12mo. Lond., pp. 125–129. 1674.

"The cinder like scum swims upon the melted metal in the hearth, and is let out once or twice before a *Sow* is cast.

"*The manner of working the Iron at the Forge or Hammer.*

"In every forge or hammer there are two fires at least, the one they call the Finery, the other the *Chafery*.

"At the Finery by the working of the hammer they bring it into *Blooms* and *Anconies*, thus.

"The Sow at first they roll into the fire, and melt off a piece of about three-fourths of a hundred weight, which, so soon as it is broken off, is called a *Loop*.*

"This Loop they take out with their shingling tongs, and beat it with Iron sledges upon an Iron plate near the fire, that so it may not fall in pieces but be in a capacity to be carried under the hammer. Under which they then removing it, and drawing a little water, beat it with the hammer very gently, which forces cinder and dross out of the matter, afterwards by degrees drawing more water they beat it thicker and stronger till they bring it to a *Bloom*, which is a four-square mass of about two foot long. This operation they call *shingling the Loop*.

"This done, they immediately return it to the Finery again, and after two or three heats and working they bring it to an *Ancony*, the figure whereof is in the middle, a barr about 3 feet long of that shape they intend the whole barr to be made of it; at both ends a square piece left rough to be wrought at the *Chafery*.

"*Note.*—At the *Finery* 3 load of the biggest coals goe to make one tun of Iron.

"At the *Chafery* they only draw out the 2 ends suitable to what was drawn out at the *Finery* in the middle, and so finish the barr.

"*Note.*—1. One load of the smaller coals will draw out one tun of Iron at the *Chafery*.

"2. They expect that one man and a boy at the *Finery* should make 2 tuns of Iron in a week; two men at the *Chafery* should take up, *i.e.*, make or work five or six tun in a week.

"3. If into the hearth where they work the Iron-sowes (whether the *Chafery* or the *Finery*) you cast upon the Iron a piece of Brass, it will hinder the metal from working, causing it to spatter about, so that it cannot be wrought into a solid piece."

There is no mention of *flux* in this description. It may be that the ore itself served as a flux, as already stated, but if calcined clay-ironstone alone were used, some limestone must have been added. Chalk may have served for this purpose; I have found fragments of this in old cinder heaps. The Ashburnham limestones and the Paludina marbles of the Weald Clay may also have been used.

The quantities used at Ashburnham furnace are given by DALLAWAY as follows:—"According to the present practices to

* In the Catalan process the mass of malleable iron *first* obtained is termed *Loupe* or *Massé*.

make thirteen tons of pig-iron require fifty loads of charcoal (two cords of wood make one load of charcoal, and two of them a weighing load), and fifty loads of ironstone, twelve bushels to each load."*

The foregoing account of RAY'S is dated 1674; in 1678 there was published a description of the processes adopted in the Forest of Dean, so closely resembling those used in the Weald that it may be worth while repeating it here:†—

"The Iron-Ore, which is the principal manufacture here, and by which most of the Inhabitants subsist, is found in great abundance in most parts of the Forest, differing in colour, weight, and goodness. The best, which they call their Brush-Ore, is of a Blewish colour; very ponderous, and full of little shining Specks like grains of Silver. This affords the greatest quantity of Iron; but being melted alone produceth a Metal very short and brittle, and therefore not so fit for common use.

"To remedy this inconveniency, they make use of another sort of Material, which they call their Cynder, and is nothing else but the Refuse of the Ore after the Metal hath been extracted; which being mingled with the other in due quantity, gives it that excellent temper of Toughness for which this Iron is preferred before any that is brought from Forein parts.

"But to understand this rightly, it is to be noted, that in former times, when their Works were few, and their Vent small, they made use of no other Bellows, but such as were moved by the Strength of men; by reason whereof their fires were much less intense than in the Furnaces they now employ. So that having in them melted down only the principal part of the Ore; they rejected the rest as useless and not worth their charge. This they call their Cynder, which is now found in an inexhaustible quantity through all parts of the Countrey where any former Works have stood.

"After they have provided their Ore, their first work is to Calcine it, which is done in Kilns, much after the fashion of our ordinary Lime-Kilns. These they fill up to the top with Coal and Ore, *stratum super stratum*, until it be full; and so putting Fire to the bottom they let it burn till the Coal be wasted, and then renew the Kilns with fresh Ore and Coal in the same manner as before. This is done without fusion of the Metal. . . .

"From hence they carry it to their Furnaces, which are built of Brick or Stone, about 24 foot square on the outside, and near 30 foot in height. Within, not above 8 or 10 foot over, where it is widest, which is about the middle; the top and bottom having a narrower compass, much like the shape of an Egg. . . .

"Behind the Furnaces are placed two huge pairs of Bellows, whose Noses meet at a little hole near the bottom. These are compressed together by certain Buttons, placed on the Axis of a

* Hist. of Western Division of Sussex, vol. i. p. clxiii.

† An Account of the Iron Works in the Forest of Dean, by H. POWLE. *Phil. Trans.*, vol. xi. p. 931.

very large Wheel, which is turned about by Water, in the manner of an Overshot-Mill. As soon as these buttons are slid off, the Bellows are raised again by the counterpoise of weights; whereby they are made to play alternately, the one giving its blast all the time the other is rising.

"At first they fill these furnaces with Ore and Cynder intermixt with Fuel, which in these Works is always of Charcoal; laying them hollow at the bottom, that they may more easily take fire: But after they are once kindled, the Materials run together into a hard cake or lump, which is sustained by the fashion of the Furnace, and through this the Metal, as it melts, trickles down into the Receivers, which are placed at the bottom, where there is passage open, by which they take away the Scum and Dross, and let out the Metal as they see occasion.

"Before the Mouth of the Furnace lies a great Bed of Sand, wherein they make Furrows of the fashion into which they desire to cast their Iron. Into these, when their Receivers are full, they let in their Metal; which is made so very fluid by the violence of the Fire, that it not only runs to a considerable distance; but stands afterwards boiling for a good while.

"After these Furnaces are once at Work, they keep them constantly employed for many Months together, never suffering the Fire to slacken night nor day; but still supplying the waste of the Fuel and other Materials with fresh, poured in at the top.

"Several attempts have been made to bring in the use of Sea-coal in these Works, instead of Charcoal; the former being to be had at an easie rate, the latter not without great expense; but hitherto they have proved ineffectual. The Workmen finding by experience, that a Sea-coal Fire, how vehement soever, will not penetrate the most fix'd parts of the Ore, and so leaveth much of the metal unmelted.

"From these Furnaces, they bring their Sows and Pigs of Iron (as they call them) to their Forges. These are of two sorts, though standing together under the same Roof; one they call their Finery, the other the Chafery. Both of them are open Hearths, on which they place great heaps of Sea-coal, and behind them, Bellows, like to those of the Furnaces, but nothing near so large. Into the Finery they first put their pigs of Iron, placing three or four of them together behind the fire, with a little of one end thrust into it. Where softening, by degrees they stir and work them with long Bars of Iron, till the Metal runs together into a round Mass or Lump, which they call a Half-Bloom. This they take out, and giving it a few strokes with their Sledges, they carry it to a great weighty Hammer, raised likewise by the motion of a Water-wheel; where, applying it dexterously to the blows, they presently beat it a into thick short square. This they put into the Finery again, and heating it red hot, they work it out under the same Hammer, till it comes into the shape of a Bar in the middle, with two square knobs in the ends. Last of all, they give it other Heatings in the Chafery, and more workings under the Hammer, till they have brought their Iron into Bars

of several shapes and sizes; in which fashion they expose them to Sale.

"All their Principal Iron undergoes all the forementioned preparations; yet for several purposes, as for the Backs of Chimnies, Hearths of Ovens, and the like, they have a sort of Cast Iron; which they take out of the Receivers of the Furnace, so soon as it is melted, in great Ladles, and pour it into moulds of fine Sand; in like manner as they cast Brass and other softer Metals; but this sort of Iron is so very brittle, that being heated, with one blow of a Hammer it breaks all to pieces.

"Though this fault be most found in this sort of iron; yet, if in the working of their Best sort they omit any one Process, it will be sure to want some part of its Toughness, which they esteem its perfection."

We have no information as to the *yield* of the early Wealden furnaces. In 1740 the four furnaces in Kent produced on an average only 100 tons each, those of Sussex 140 tons. With the exception of Caermarthen, where one furnace gave 100 tons, all the other counties gave larger returns; those of Cheshire gave 567 tons each. The total produce of England and Wales in 1740, from 59 *charcoal* furnaces, was 17,350 tons of iron, averaging 294 tons each.*

It seems probable that little alteration took place in the mode of working in Sussex during the decline of the trade; for, whilst the annual amount produced by each furnace rapidly increased in other districts, here it was almost stationary.

The following extract gives a little information as to the management of the ironworks:†—

"At Sheffield there was a furnace for casting raw iron only, with 23 workmen; at which 14 oxen were employed for draught, with two wain-men, and a hammer mill, the iron of which had been sold for 8*l.* 12*s.* a ton, and some had been taken, amongst other places, to the White Hart in Southwark, which had been Jack Cade's head quarters, and which is fully noticed in Mr. Corner's paper on the Inns of Southwark, in the 2nd vol. of Collections of the Surrey Arch. Society (p. 64). In the Forest of Worth there was a double furnace to cast ordnance and shot, as well as raw iron, and a forge also, at which 33 workmen were employed. All the workmen were paid by task work, but over each forge was a manager to superintend the work and workmen, and weigh the iron, with a yearly salary of 4*l.* and a livery, or 10*s.* and meat and drink."

In the Lower Boulonnais there are now ironworks in which ore from the Wealden Beds is used. In the north-eastern part of the district the Wealden Beds lie immediately on Carboniferous and Devonian Limestones, and the ore is got by shafts. M. De-

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* Encycl. Brit., 8th Ed., 1856, Article "Iron" (by Sir W. Fairbairn).

† Sir Henry Ellis, "Inventories of Goods, &c. . . . . belonging to the Lord Admiral Seymour, at the time of his attainder, taken 1594. *Sussex Arch. Coll.*, vol. xiii. p. 119. The Sheffield here spoken of is four miles west of Uckfield.

LANOÜE says the ironstones raised at Ferques are "sometimes superficial, and therefore hydrated ores, peroxidized and concretionary, with mottled clay and sands, ... and sometimes carbonates and sulphide of iron in the midst of bituminous clays. Wherever atmospheric influence has made itself felt, in former times or now, the sulphuric and carbonic acids have been replaced by oxygen and water."*

In the neighbourhood of Boulogne the ore is got by open workings; it consists chiefly of hydrated peroxide, often with a considerable quantity of sand. I extract the following from a memoir which has appeared elsewhere:†—

"There are large blast-furnaces at Marquise, and at Outreau, near Boulogne. At Marquise, according to M. S. Jordan,‡ the ironstone is mixed with ore from Africa, chalk and other limestones of the district being used for flux; at Outreau the native ore is mixed with Cumberland hæmatite. An analysis of Boulonnais Wealden ore gave 49·14 per cent. of peroxide § (=34·39 per cent. of iron). Some account of the smelting of this ore, and of comparisons with other works in the north of France, is given in a paper by M. Leducq, read at the Society of Agriculture of Boulogne in 1834.‖ These furnaces are all of recent origin; no mention is made in Rozet's Memoir (1828) of the ore being worked, nor in Bertrand's "Histoire de Boulogne" (1829). M. Henry, in 1804,¶ alluding to the great quantity of iron-ore in the district, stated that the only obstacle to smelting it was want of fuel. Coke is now chiefly got from Belgian coal."

It is not a little singular that the Boulonnais ironworks should have started close at the time that those of the Weald died out. The last Wealden furnace, at Ashburnham, was put out in 1828. Those of the Boulonnais began between 1829 and 1834.

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* *Bull. Soc. Geol., France*, Ser. 2, tom. ix. p. 403, 1852.

† *Quart. Journ. Geol. Soc.*, vol. xxiv. p. 480, 1868.

‡ CUYPER'S "Revue de l'Exposition Universelle de 1867," p. 416.

§ *Ibid.*, p. 414.

‖ "Du Développement de la Production du Fer dans le Nord-ouest de la France, Procés Verbal," p. 183. 8vo. 1835.

¶ "Essai historique . . . sur . . . Boulogne-sur-mer." 4to, p. 255. (Printed 1804 published 1810.)

CHAPTER XX.—COAL.

At various times there have been reports of the existence of coal in Sussex, and some attempts have been made to sink to coal seams which were supposed to lie beneath the surface. The discovery of coal in this district would be of immense value; for, besides supplying the metropolis with fuel, it is possible that if coal were obtained on the spot, the old ironworks might in some places be resumed.

There is a general surface resemblance of the Weald to some coalfields, which has seriously misled many persons in former days. The alternations of clays, shales with clay ironstone, and sandstones, in the Hastings beds, produce features which do not greatly differ from those assumed by similar beds in some coalfields. This is especially the case with the "gills," the steep sides of which are formed by sandstone; these very strikingly resemble the wooded "denes" of Northumberland and Durham.

The occurrence of thin seams of coal or lignite would suffice to convince many persons of the similarity of the strata which external appearances had suggested. I am not aware if the early searchers for coal in Sussex gave any notice to the fossils found in the rocks; but if such objects attracted their attention they would certainly refer the *Unios*, *Equisetums*, and *Ferns* of the Wealden Beds, to the *Anthrocosias*, *Calamites*, and *Ferns* of the Coal Measures.*

In the foregoing pages lignite has frequently been mentioned as occurring in various parts of the Wealden Beds. That at Newick Old Park has been described by Dr. Mantell; the bed is said to be "of the Bovey kind," eleven inches or more in thickness. "The Newick coal in my possession has very much the character of jet: it is of a velvet black, does not soil the fingers, has a resinous lustre, and a conchoidal fracture; it is very brittle, and burns with a bright flame."† This is in the Tunbridge Wells Sand. The discovery, in 1801, of a bed somewhat thicker than usual, gave rise to much discussion. This was found (in Ashdown Sand) in the bed of a brook dividing the parishes of Heathfield and Waldron, and from it was obtained "a block of jet black and pure coal of the Kendal [Cannel] species, nearly resembling the size of a stout man . . . . A blacksmith whose shop was at hand, took away enough of the uncovered beds to suffice him for a fortnight, and he declared that he never worked more pleasantly,

* "Vegetable impressions" are mentioned as being found in the sinking at Bexhill, and they were taken as indicating the presence of coal; but their precise nature is not stated (*see* Dickson's *Agric. Mag.*, vol. ii., p. 28, 1808). The general resemblance of the Weald to some coal fields has been noticed by Dr. Fitton, who says:—"The borings.....at Bexhill were much more excusable than has been supposed." *Geol. of Hastings*, p. 49.

† Fossils of the South Downs, p. 34.

or with a better fire. It burnt with a short, strong, blue flame. Several persons also tried it at the grate with similar satisfaction."* One or two other localities in the neighbourhood are noticed. "Brown's Lane, in Waldron, has long produced ample specimens, insomuch that a travelling tinker, named Lindsey, often replenished there his exhausted stock, until he fancied that the smell affected his head, as it happened to be overladen with sulphur or the like."

There was much talk of sinking a shaft here, and professional advice was obtained to that end, but the scheme was ultimately abandoned. "From what cause Mr. Fuller [the proprietor] abandoned the pursuit, I know not. I only know that some threats of legal action were thrown out against the undertaking, and a fellow of the name of Farey wrote largely, in a ridiculing style, against the idea of finding coal in Sussex. His ignorance and abuse will be best seen by a reference to the *Lewes* Journal in the year 1808."

I have not seen the letter in the "Lewes Journal," but MR. FAREY'S opinions, neither ignorant nor abusive, were stated in Dickson's Agricultural Magazine for 1807 and 1808.† They were founded upon a personal examination of the district and were quite averse to the possibility of finding workable coal in these beds.

During the years 1804–9 a shaft was sunk at Bexhill, at a great cost, in hopes of finding coal. Some seams of lignite were passed through, reported to vary in thickness from 2 feet 3 in., to 4 feet 6 in.; the thickest seam is said to be of bad quality and very sulphureous.‡ These seams are thicker than any known to occur at the surface; and, supposing the section to be reliable, it is very remarkable that the shaft should happen to be sunk at a spot where these beds, usually thin and very inconstant, had attained their greatest known thickness. It is, however, very doubtful if these beds really were found, or there would surely have been some more serious attempt to work them. LOWER speaks of sanguine adventurers being induced to sink a shaft here, and he adds, "adventurers of another kind encouraged the scheme and fictitious specimens of coal were brought to the surface." §

The following note was published in 1806:—"The success which attended the research for coal at Bexhill, has stimulated others to similar pursuits, in situations equally promising. At Rotherfield several men are actively employed in boring, and at Maresfield some good specimens have been obtained."‖

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* See a statement by MR. J. HARMER, communicated to the "Brighton Guardian" in June 1830 (quoted by MR. LOWER, *Suss. Arch. Coll.*, vol. ii., p. 211).

† Vol. i., p. 115, and vol. ii., p. 22.

‡ The details of the section are given by DR. MANTELL; *Fossils of the South Downs*, p. 36.

§ *History of Sussex*, vol. i., p. 49.

‖ *Monthly Magazine*, vol. xxii., p. 95. I know nothing of the boring at Rotherfield beyond the brief notice here given. I should be very grateful for further information, if any such exists.

MR. TOWNSEND, writing in 1813, and speaking of fruitless searches for coal, says,—* "I understand that a similar trial, with similar success, has been made near Horsham, in Sussex." I have been unable to find any further account of this; probably the trial at Bexhill is here referred to.

Of late years some attention has again been paid to the beds of lignite. In the "Engineer" for 1868 (pp. 327 and 344), special mention was made of those exposed upon the shore west of Bexhill.† The following analysis by MR. T. W. KEATES, of Wealden lignites, were then published; the exact localities of each are not given:—

	A.—Tender and Friable.	B.—Hard and Compact.
Volatile matter, including moisture -	49·10	48·40
Fixed Carbon - - -	47·65	33·50
Ash - - - - -	3·25	18·10
	100·00	100·00
Sulphur - - - -	0·87	0·88
Coke - - - - -	50·90	51·60
Specific gravity - - -	1·275	1·346

It is doubtful if such thin and inconstant beds of lignite as occur in the Weald will pay to work, at least for many years to come; and if coal is to be obtained from the Weald it must be by sinking to the underlying Palæozoic rocks.

The history of this question, suggested as early as 1846 by SIR H. DE LA BECHE,‡ and so ably worked out by MR. GODWIN-AUSTEN,§ is too well known to need repeating here. The presence of the Palæozoic rocks at moderate depths beneath the south-east of England is no longer a matter of conjecture; they have been proved at Harwich and at Kentish Town; and we may hope that they will soon be proved in the Weald. But whether or not they will contain coal measures is quite another question. The faint hope that they may do so under the Weald lies in this; that in the Palæozoic ridge in the northern part of the Bas Boulonnais the Carboniferous Limestone is dipping south, where last seen to disappear under the Oolitic rocks; in the Pays de Bray, near Gournay, Carboniferous Limestone has been found immediately under the Kimeridge Clay. It is, then, possible that a little south of the Bas Boulonnais, and in the country south of this, there may be a trough of coal measures, which may possibly be prolonged westwards under the Weald.‖

The "Sub-Wealden Exploration," however, was not started with the object of finding coal measures. MR. HENRY WILLETT proposed this in connexion with the visit of the British Associa-

* *The Character of Moses*..... p. 428.

† *See* also *Engineer* for Aug. 2, 1872, and the *Mining Journal*, March 25 and April 1, 1871.

‡ *Mem. Geol. Survey*, vol. i., p. 214.

§ *Quart. Journ. Geol. Soc.*, vol. xii., p. 38, 1856.

‖ This was pointed out by MR. GODWIN-AUSTEN at the first meeting of the Sub-Wealden Exploration Committee.

tion to Brighton in 1872, and his intention was and is to explore the rocks which underlie the Weald. That whatever information the boring may give will aid in solving the coal question, and that there is a faint hope that coal measures may occur beneath the Weald, are no doubt weighty reasons why so many people take an interest in the undertaking; but it cannot be too often stated that the promoters of the boring are not searching for coal, but are merely proving the succession of rocks beneath the Weald.

It is to be hoped that, whatever the result of this boring, it may be only the first of a series which shall thoroughly explore the palæozoic geology of the south-east of England, and it may perhaps, be well here to point out some other sites wherein future borings may advantageously be made.

In an earlier part of this Memoir (p. 241) I have briefly endeavoured to shew that the apparent upheaval of the Weald or the dip of the beds away from the centre is not wholly due to movements of the strata, but that it may partly be due to inequalities of original deposition; and that the observed general dips of the higher beds, as now exposed at the surface, may but slightly affect, if at all, the underlying Palæozoic floor.

However this may prove to be, it is very probable that the great flexures which traverse the south-east of England are in great part due to movements which have also affected the Palæozoic floor; probably also most of the minor anticlinals will have had a similar origin.

In fixing upon the sites of future bore-holes we should have regard to these lines of probable upheaval, as along them we may reasonably hope to reach the Palæozoic rock at less depths than in the districts *immediately* north and south of them. We should also select spots along valleys, where the higher rocks have suffered most from denudation. It will be important in all cases to bore at the crown of the anticlinal, or in places where the dip is small, so that the beds should not be cut obliquely.

In the map (Plate II.) at the end of this Memoir the chief anticlinal lines are shown, and in the following table I have drawn up a list of places which are best adapted for boring. They are taken in nearly parallel lines from west to east. The general positions of these may be known by reference to the maps given with this Memoir, but the exact value of each can only be ascertained by consulting the one-inch Geological Map and the Geological Survey Sections.

So far as we know at present, these points are of nearly equal value for boring, for the greater thickness of higher beds which may have to be pierced by those to the north, will be balanced by the absence of many of the lower beds which will be present in the borings further south.* But what special site should be chosen for a second bore-hole, if started after that now in progress

* *See* the section on Plate VI., opposite page 242.

is finished, will depend entirely upon what we learn by that now going on.

List of Sites, in and near the Weald, which are favourable for Boring to the Palæozoic Rocks. (Taken in successive N. and S. or N.E. and S.W. lines from West to East.)

1. Valley of Kingsclere.	Upper greensand exposed; the southern side where beds are flat.
2*a*. Pease Marsh near Guildford.	Weald clay inlier, brought up by anticlinal.
b. Windsor.	Chalk brought up by flexure.
3*a*. Crowborough Mill, N.E. of Crowborough Beacon.	Low beds of the Ashdown Sand exposed by anticlinal and denudation.
b. Penshurst.	Ashdown Sand.
c. Sevenoaks, a little north of the tunnel.	A disturbance brings up the Atherfield Clay at the mouth of the tunnel, but a little north of this the beds are flat.
d. Crossness.	Bore hole already down 960 feet below the sea level, and 147 feet into the Gault.
4*a*. Netherfield.	Present Sub-Wealden Bore hole.
b. Goudhurst, valley west of.	Ashdown Sand exposed by anticlinal and denudation.
c. Maidstone.	Weald Clay brought up near the Chalk.
5*a*. Fairlight.	Anticlinal bringing up the lower part of the Fairlight Clays, not far above the Purbecks.
b. Rye.*	Bore hole already down 330 feet into the Fairlight Clays.
c. St. Margaret's Bay.	Bore hole already down to Upper Greensand, 540 feet below sea level.

* Mr. WHITAKER has pointed out to me that Dunge Ness would be a good spot, it being geographically nearer to the exposure of the Palæozoic rocks in the Bas Boulonnais than most of those mentioned. This is certainly a point of some importance; but it should be borne in mind that here the boring would probably be through silt for 60 or 80 feet, and it is quite uncertain which of the Wealden beds would be struck below this; it would probably be low in the series, but it might be rather high.

CHAPTER XXI.—SPRINGS AND WATER SUPPLY.

Of the wells and springs in the Wealden Beds it is not necessary to say much. Water is difficult to get over the Weald Clay districts, wells being generally of no avail unless they touch a sand or marble bed. Wells near the outcrop of the Hastings Beds generally obtain a good supply; those sunk through the Wadhurst Clay often obtain water in the Ashdown Sand, which from its great expanse over high ground is generally found to be well stored with water when tapped at lower levels. The water from the Wealden Beds is, however, liable to be slightly chalybeate. That from the well at Hayward's Heath Asylum is so; the following is an analysis of the water by DR. TAYLOR*:—

	Grains in Imp. Gal.
Carbonate of Lime	7·20
„ Magnesia	0·69
„ Soda	2·80
Sulphate of Lime	2·40
„ Soda	1·06
Oxide of Iron	0·13
Organic matter	0·95
Phosphoric Acid, Silica, and Alumina	traces
	15·23

The iron is stated to exist in combination with organic matter; besides that given in the analysis there are 0·54 grains of insoluble floating matter, separable by filtration, which is also iron in a like condition.

DR. TAYLOR supposes the iron to be introduced from the surface, but in the well section (given on p. 88) there is a bed of iron pyrites, from which it possibly comes; but in that case its combination with organic matter is not so easily explained.

The chalybeate springs at Tunbridge Wells are too well known to need description here. Probably more has been written on them than on any other medicinal wells in England, save those at Bath. The titles of such books and papers as I have met with are given in Appendix III. Perhaps the latest analysis is that by MR. J. THOMSON, which I here reprint:—"The chief characteristic of this water seems to be its extreme purity, its principal constituent being iron held in solution by the agency of free carbonic acid."

* For this analysis, and for the information given on p. 88, I have to thank the authorities of the Asylum.

	Grains in Imp. Gal.
Sulphate of Lime	2·1000
Carbonate of Lime	0·4494
„ Magnesia	1·1172
Chloride of Potassium	0·2345
Carbonate of Potassa	0·5978
Chloride of Sodium	3·1780
Carbonate of Iron	3·9123
„ Magnesia	trace
Silica	0·5250
Organic matter	trace
	12·1142

Free Carbonic Acid (at mean temp. and pressure) 19·19 cubic inches. The temperature of the spring is always 10° C. (50° Fahr.), and its yield from 3·13 to 3·33 gallons per minute.*

There are other wells in the neighbourhood, which at one time were of some note. Adam's Well, at Speldhurst, was perhaps the most celebrated; but this had, even in 1766, so far degenerated as to be "only famous for the cure of mangy dogs."†

The shingle-flats, which stretch out to sea at Dunge Ness and Langley Point, are not destitute of fresh and good water. Wells are sunk through the shingle, and a supply of water is obtained which rarely or never fails. At Langley Point there are wells within 50 yards of the shore which are only slightly brackish in very dry weather; at all other times the water is quite fresh.

The Upper Greensand terrace is always well supplied with water. Springs break out at the foot of the Chalk escarpment, and furrow the terrace; others break out at the foot of the terrace itself. "Our wells," says GILBERT WHITE, "at an average, run to about sixty-three feet, and when sunk to that depth, seldom fail; but produce a fine limpid water, soft to the taste, and much commended by those who drink the pure element, but which does not lather well with soap."

The Lower Greensand generally has springs at the foot of its escarpment; and, where the clayey beds of the middle division exist, there is often a line of springs at the bottom of the Folkestone Beds. The most powerful springs are in those valleys which are cut through the Hythe Beds to the Atherfield Clay below. Generally these valleys are enabled to reach the clay in consequence of the latter being brought up by anticlinals, such as have already been described in Chapter XIV., and which will be further alluded to immediately.

The springs of the Hindhead district do not for the most part arise from this cause, save that at the Devil's Punch Bowl. They may be thrown out by clayey beds in the rock, or more probably by the valleys reaching the line of saturation.

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* *Journ. Chem. Soc.*, vol. x. p. 223, 1858.

† BURR'S *Hist. of Tunbridge Wells*, 8vo. Lond., p. 27, 1766.

The Lower Greensand of West Surrey (together with the Bagshot area to the north) was proposed in 1850 as a source of water supply for London, and many reports were published upon it by various engineers and others, the titles of which will be found in Appendix I. (see the years 1850–1–2). The HON. W. NAPIER proposed to collect the spring waters only, or with such other water as could be collected by tapping the springs according to ELKINGTON'S system of drainage. The total quantity obtainable from the Greensand and Bagshot districts, he stated at nearly 40,000,000 gallons daily.

From MR. NAPIER'S gaugings I calculate the daily yield of the Lower Greensand separately, as follows* :—

				Gallons.
From 15 springs and rivulets in			Hindhead and Black Down -	20,988,738
4	,,	,,	Hascombe Hills - -	2,049,808
3	,,	,,	Leith Hills - - -	4,127,154
				27,165,700

The whole of this quantity is stated to be at or under 1° of hardness.

Subsequent observers give varying results, some of them exceeding MR. NAPIER'S estimate in yield, but all giving a greater degree of hardness. MR. BATEMAN found 33,000,000 gallons daily from the Lower Greensand, averaging $2\frac{1}{6}$° of hardness.†

From MR. NAPIER'S investigations it appears that springs are softer than streams and wells; he states that, in the district in question, waters stand for purity in the following order :—

1. Springs issuing from pure sands.
2. Collections of rain water [ponds, &c.].
3. Water running through ordinary loamy soils.
4. Well waters.

The streams get harder as they flow; thus, the Bramshot a little above its junction with the Wey is 5°, at Bramshot $1\frac{1}{2}$°, and higher up still only $\frac{1}{2}$°.‡

Several analyses of the waters are appended to MR. NAPIER'S Report. A special examination of their chemical quality was made by MESSRS. GRAHAM, MILLER, and HOFMANN, from whose report I extract the following analyses.§ The first column headed "Farnham," is water supplied to that town from the Bagshot district. It may be compared with the remaining six, all of which are from Hindhead.

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* It should be observed that these and other figures of MR. NAPIER'S Report have been rather severely criticised. See, amongst others, ROWLANDSON'S Report, 1851; and HUGHES' *Treatise on Waterworks*, 1856, p. 63, &c.

MR. J. LUCAS, in his *Horizontal Wells*, 1874, has collected much information as to the yield of springs flowing from the Lower Greensand.

† Quoted from HUGHES' *Treatise on Waterworks*, p. 73.

‡ NAPIER'S Report, p. 10.

§ *Parl. Reports*, 1851, and *Quart. Journ. Chem. Soc.*, vol. iv. p. 375.

—	Farnham.	Spring flowing into Sweet Water, Witley.	Critchmere Springs.	Vellwood, 1½ mile from Haslemere.	The Punchbowl, near the summit of the Hindhead.	Barford Millstream.	Spring at the Moors, Gosford House.
	Grains in an Imperial Gallon.						
Carbonate of lime -	0·23	—	—	—	—	2·39	8·31
Sulphate of lime -	1·31	1·32	1·07	0·86	0·59	0·40	2·48
Silicate of lime -	—	0·65	—	0·45	1·00	—	1·17
Nitrate of lime -	Trace	—	Trace	—	—	—	—
Silicate of magnesia -	—	—	—	—	0·30	—	—
Carbonate of magnesia	0·64	0·43	Traces	Traces	—	0·27	0·60
Chloride of sodium -	0·93	1·14	0·88	0·87	0·74	0·94	1·40
Sulphate of soda -	0·07	—	—	0·44	0·04	—	0·22
Chloride of potassium -	—	0·31	0·26	—	—	0·03	—
Sulphate of potassa -	0·43	—	0·03	0·40	0·09	0·20	0·77
Silica - - -	0·99	0·45	1·00	0·93	0·10	0·72	—
Iron, alumina, and phosphates.	0·88	—	—	—	0·02	0·08	0·08
Organic matter -	1·78	1·11	0·90	1·24	1·30	1·05	0·95
Total - -	7·26	5·41	4·14	5·19	4·18	6·08	15·98
Solid residue obtained on evaporation.	7·33	5·31	4·37	5·17	4·34	5·65	15·75
Free carbonic acid -	Trace	Trace	Trace	Trace	Trace	Trace	Trace
Hardness - -	2·27	1·95	1·86	1·86	2·45	2·70	10·8

The Hindhead waters "were pure and brilliant, and entirely unexceptionable in point of aeration and colour. Their usual temperature when taken up was from 50° to 52°, showing that their sources are deep seated, and preserve the average temperature of the whole year. Their taste betrayed no organic taint, but evinced great purity, although they appeared rather flavourless, and somewhat vapid to persons habituated to the use of hard water. Their hardness proved extremely low, except that of the spring at the moors near Gosford House, which was of 10·8 degrees of hardness, but this is evidently a water of a different character from the others."

Excluding the Farnham water and Gosford House spring, the average hardness of the remaining five is 2·1. "The value of this extreme purity and softness is not diminished by the other mineral and organic constituents of the waters, which are insignificant in quantity, and really of no account. The nearly entire absence of carbonic acid from these waters, to which attention has been drawn by Mr. Napier, is perhaps their most singular chemical feature." (Parl. Report, p. 11.)

The following analyses, by Dr. E. Frankland and Dr. Odling, are taken from the report of the Royal Commissioners on Water Supply, 1869. (Appendix A.X. (2.) p. 104.) Only one of the localities is actually within our district, but the others may be useful for comparison.

—	R. Wey, above Godalming.	R. Mole.	Artesian Well at Caterham	Stream from Bagshot Sands, near Sandhurst College.
	I.	II.	III.	IV.
Total solid residue from 100,000 parts of water evaporated and dried at 100° C.	14·83	23·51	31·08	7·05
Mineral substances in 100,000 parts of each water:—				
Lime	4·72	8·92	10·60	·68
Magnesia	·50	·81	2·48	·35
Potash	·33	·37	1·11	·37
Soda	1·09	1·79	1·44	1·08
Sulphuric acid	·90	1·64	1·96	·549
Carbonic acid	3·81	8·12	10·66	·81
Silica	1·23	·77	2·59	·92
Chlorine	1·42	1·78	1·35	1·36
Nitrogen as nitrates and nitrites	·079	·231	·027	·000
Ammonia	·001	·000	·000	·003
Organic substances in 100,000 parts of each water:—				
Organic nitrogen	·065	·022	·006	·043
" carbon	·538	·166	·020	·909
Hardness in 100,000 parts of each water before boiling.	8·3	16·1	23·4	1·5
Hardness in 100,000 parts of each water after boiling.	8·0	4·4	9·0	1·5

Remarks by W. POLE [Appendix O, p. 69]: No. I. "Taken on the 21st April [1868] about three-quarters of a mile above Godalming; river somewhat in flood and rather turbid; temperature about 13° Cent. [55·4 Fahr.] No. II. Taken on the 4th May, about one mile above the junction and above the village of Moulsey. Water dirty and turbid, bottom hardly visible 1 ft. deep. No. III. Taken on 12th May. The water is pumped from a very deep well, the water standing about 300 or 400 feet below the level of the ground at the pumping station, which is 700 feet above the sea. . . . . The sample . . . . was taken from the pumping main, as it came directly from the well, and probably represents fairly the chalk water of the North Downs. The temperature was 11° Cent. [51·8 Fahr.] No. IV. Taken on the 21st April, about a mile above the College; temperature about 11° Cent. The water was clear, but a little coloured by peat, and the channel presented appearances probably due to iron."

The importance of a correct knowledge of the water-bearing qualities of the Lower Greensand of Kent and Surrey, as bearing upon the water supply of London, can scarcely be overrated. If it be proposed to collect the water *on* the Lower Greensand, and to carry it by aqueducts to London, the problem is comparatively simple; and can easily be answered by ascertaining how much water can be so collected. Simple as this appears, and as it

certainly is, there have been some most discordant results obtained. But this plan is not now in favour, and there appears to be a decided preference for the scheme of supplying London from the *underground* store of water, supposed to be contained *in* the Lower Greensand. The Royal Commissioners on Water Supply laid great stress upon this in their Report; a part of which I here reprint:—

"It is known that the Lower Greensands exist at Reigate and are about 450 feet thick, and that they occur again in Bedfordshire with a thickness of about 200 feet. In both cases they dip towards London, disappearing beneath the gault. We know that they do not exist under London (Kentish Town). It follows, therefore, that in the one case they cease at some point between Reigate or Merstham and London, and in the other between Baldock and London. As at both ends they are of considerable thickness, and the gault is continuous, it is certain that the greensands must range from these outcrops some way towards London, probably thinning off gradually against the flanks of the underground ridge of old rocks. So far as they continue, so far will they form a valuable and copious water bearing bed, the water from which would overflow at the levels lower than that of their outcrop. The extent of their underground range could only be determined by boring. It might be as far as Croydon, or even still nearer to London. The same would happen to the north of London, but the distance there is greater, the beds are not so thick, and the conditions generally are less favourable. The great purity of the water from the Grenelle and other artesian wells in the Lower Greensand is well known, and there is reason to suppose that the quality of the water obtained from the same formation in the vicinity of London would prove equally good. The excessive length of filtration would at all events ensure freedom from organic impurities.

"The quality of the water flowing from the Lower Greensands is excellent for all domestic purposes, being bright and limpid, of a degree of hardness varying only from about 3° to 9° of Clark's test, and generally very free from organic matter." *

The success of this scheme of tapping the Lower Greensand depends evidently upon whether or not there be any great quantity of water in that formation. It is highly probable that to the north of London much of the water which falls on the Lower Greensand passes under the Gault to the south, towards London, and may be obtained by boring. But it is not from this side of the London Basin that the greatest supply is expected. Whether or not the Lower Greensand on the south of London will furnish a sufficient supply is a difficult question, and one that can only be satisfactorily solved by actual borings in that direction; but there are some *facts*, well ascertained, which have an important bearing on the question, and to these we will briefly allude.

Only so much water as falls as rain *on* the Lower Greensand can avail for underground water supply. The small quantity

* "Report of Royal Commission on Water Supply, 1869," p. 89

which may run off the Gault on to the Folkestone Beds and so drain away underground is scarcely worth consideration, but even this could be allowed for. It is certain, however, that no water falling on the Weald Clay passes away through the Lower Greensand, unless it be that the rivers are themselves in part absorbed in their passage over that formation. But this is not likely to be the case. Each river, in running through the lowest ground, determines the line of saturation, and upon this depends the height at which the springs break out in the neighbouring district. The Mole, in its passage over the Chalk, is in part absorbed in dry weather; but the water rises again lower down the valley.

If, then, we, ascertain the total area of exposure of the Lower Greensand, and also the amount of rainfall over that area, we can calculate the greatest quantity of water that can possibly avail. Of this a very large quantity drains off the surface at once into brooks, and, passing into the rivers, is carried out of the district. Another portion evaporates, either directly from the surface or through vegetation. The rest sinks into the ground, but in part re-appears as springs, which afford a constant supply of water to the brooks. If we could ascertain the total amount of water thus withdrawn, we could estimate the maximum amount which passes under the Gault and away northwards beneath the London Basin.

It is certain that a very large quantity of the water absorbed by the Lower Greensand does re-appear as springs, and it becomes a question of great importance to ascertain this amount. The quantity which it has been proposed to collect from springs and rivulets at Hindhead and Leith Hill in *part* represents this. But only in part, because no one has hitherto attempted to estimate the whole quantity which these rivulets carry off.

We may, for the purposes of this inquiry, divide the Lower Greensand area into four divisions; which are, from west to east:—

I. *Godalming:*—embracing the wide expanse of that formation around Hindhead and Leith Hill; this division coincides very closely with the Lower Greensand part of the Wey basin, excluding that part of it which lies south of Hindhead, and including a very small part of the Mole basin—that immediately east of Leith Hill.

II. *Reigate:*—the narrow outcrop of the Lower Greensand from Dorking to Limpsfield; which includes all the Mole basin (excepting the small area taken in with the first district), and also the north-western corner of the Medway Basin.

III. *Sevenoaks* and *Maidstone:*—the wide area around and to the east and west of these towns, as far east as Boughton Malherbe where the Lower Greensand again narrows. It includes the basins of the Darent and Medway, excepting the small portion of the latter included in No. II.

IV. *Ashford* and *Folkestone:*—from the eastern end of No. III. to the coast. It includes the basins of the Stour and Rother.

As we have already seen, the Lower Greensand is traversed by a series of flexures and anticlinals which must necessarily exert a great influence upon the underground passage of water. What effect such disturbances may have must be determined by each particular case, and the effect will certainly vary along the strike of each line of disturbance.

It is, perhaps, not wise to lay down rules in such doubtful matters, but I think there is sufficient evidence to justify the following conclusion:—An anticlinal line probably cuts off the supply, when valleys along this line reach down to the retentive bed. It certainly does so when the valley runs along the strike of the anticlinal (as in fig. 42, p. 222, and fig. 45, p. 230); but to a very large extent it does so when the valleys *cross* the anticlinal. Whether or not the supply is cut off when the retentive bed is not reached by small valleys along the anticlinal, will depend upon the height of the water level at the escarpment and major valleys, and the distance of each from the place in question.

With a simple *flexure* the case is different; this probably serves to carry the water quickly down below the level of springs and streams. But a flexure has the effect of narrowing the outcrop, and therefore lessening the area or collecting ground of the formation.

The most important area of Lower Greensand, as regards the water supply of London, is that of Hindhead and Leith Hill; No. 1 of the foregoing division. We cannot safely calculate on any portion of the area south of the Hindhead anticlinal; there are some rather strong springs to the south of this, about Haslemere, through which much of the absorbed rain re-appears, whilst the rest probably drains to the south and west. Some of the water which runs underground to the west, under Woolmer Forest, &c., may work its way round to the north and so avail for the supply of London; but the greater part, probably, goes to the Hampshire Basin.

The small flexure running through Thursley probably has no great effect on the water system, but on the north of that the beds, flat for awhile, rise very slightly towards the Hog's Back flexure. Upon the exact amount of this rise and the height of the line of saturation will depend the amount of water which passes over the anticlinal-flexure towards London. The strong springs near Moor Park seem to be thrown out by this flexure; and on the east, at Compton, the same disturbance brings up the Atherfield Clay and Weald Clay, thus effectually cutting off the supply in that direction. It is likely that this anticlinal flexure on the west of Pease Marsh does not completely cut off the underground supply, but it probably checks it considerably.*

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* Mr. Martin says that the Wey at Guildford is sufficiently strong to account for all the rain that falls over the district drained by it. (*Phil. Mag., Ser.* 4, vol. ii., p. 472.) I presume this is only a guess. This paper describes the flexures, &c., and the probable effect of them on the passage of water.

On the east of the River Wey, from that river to Dorking, it is probable that very little of the Lower Greensand water runs underground to the north. The springs over the district are abundant and strong, and it is likely that careful and exhaustive gauging would show that the rainfall over this area can be nearly all accounted for. The flexure shown on fig. 46 (p. 231), would not of itself probably much interfere with the flow of water, but hereabouts the Lower Greensand plateau is deeply furrowed by valleys which reach down to the Atherfield Clay, and which contain numerous springs; two such valleys are intersected obliquely in this section. The fault which ranges from the Chalk, past Park Farm (Wotton), and eastwards to the south of Berry Hill, probably aids the underground passage of water, as it throws down to the north. On the west, towards Pease Marsh, the line of disturbance is an anticlinal (see fig. 45, p. 230); and here the supply is probably cut off.

Probably much of the rain which falls on the Folkestone Beds, on the north of the line of disturbance, passes away northwards; and if much of the water from the large area of the Hythe Beds goes in the same direction it must be along the line between Albury Park and Wotton.*

The second district into which we divided the Lower Greensand, that between Dorking and Limpsfield, is in actual extent the least important of any. Notwithstanding this, and the fact that it is intersected by several stream valleys which flow from the Chalk to the Weald Clay—carrying off much surface water which would otherwise gradually percolate into the rocks—it is probably of very great importance. The flexure at Dorking (fig. 47, p. 233), and that further east at Nutfield, serve only to carry the water rapidly down to the north. The disturbance at Tilburstow Hill is near the edge of the escarpment, and, whatever its influence on the water supply, can affect but a small area. From its lying directly south of London this district is worthy of careful study as regards this question.

The third area, that of Sevenoaks and Maidstone, is of great extent, but it is of very varying importance as regards underground supply. On the south of Westerham, and from thence eastwards to Sevenoaks, there are a number of small valleys running north, which deeply intersect the plateau of Hythe Beds, and which in some cases expose inliers of Atherfield and Weald Clays.† Most of these valleys are well watered, and some have streams of con-

* This line of disturbance, and the northerly protrusion of the Weald Clay at Bury (or Berry) Hill, is noted by Mr. Prestwich, and the possibility of the whole of the Leith Hill district being excluded from the effective area is also mentioned. *Water-Bearing Strata of London*, p. 91.

† Judging from the look of the map, and comparing it with other areas in which inliers of Clay occur within the Lower Greensand area, we might expect to find an anticlinal along this line. I do not know that any occurs here. But there seems to be a slight *southerly* dip at the escarpment south of Westerham, where the landslips have taken place. This of course gives an anticlinal arrangement of the beds, but it lies close on the edge of the escarpment, about on the watershed.

siderable size, considering the small length of their courses. All these streams flow into the Darent. Towards Sevenoaks some of the water in these valleys is probably carried underground by the flexure (see p. 234); but it is certain that a large quantity rises again in the very strong springs around Riverhead and Bradbourn.

In driving the railway tunnel just west of the town of Sevenoaks the work was greatly impeded by the enormous quantity of water retained in the Hythe Beds.

In this western part of the Darent Basin there would be no difficulty in estimating very closely the amount of water which drains underground beneath the Gault. Gaugings of the Darent, after and during dry weather, at any point south or east of Rye House would give the amount of spring water supplied from the Chalk and Lower Greensand. The former might probably be estimated without great difficulty by a series of observations taken along the outcrop of the Gault; for, although the springs along this line are numerous they are not here of any great power. By deducting this amount from the total quantity of water carried past Rye House, we should have the quantity of water supplied by the Lower Greensand springs.

We may take 16 sq. miles as the area of Lower Greensand draining into the Darent, west of Sevenoaks. Probably the rainfall over this area averages 28 in., two-thirds of which may be considered as sinking into the ground. This will give slightly over 12 millions of gallons daily. If the amount carried past Rye House (after the before-mentioned deduction) be subtracted from this, we have the probable quantity of water which passes under the Gault.

The River Darent has been gauged at Shoreham, and was there found to carry 2,080 cubic feet of water per minute,* which is equal to 19 millions of gallons per day. This estimate includes the very strong Chalk springs at Orpington, and also the water carried into the Darent from the east and north-east of Sevenoaks.

The quantity of water carried past Shoreham is very large considering the area drained:—about 50 sq. miles. It is about 41·6 cubic feet per square mile of drainage, a very high figure; and, as the Chalk springs at the escarpment are neither more numerous nor more powerful than elsewhere, we must assume that the unusual quantity is owing to strong springs from the Lower Greensand. We have to deduct the springs at Orpington from the foregoing calculation; but although these are very strong springs the deduction will certainly not bring the discharge of the Darent down to the average.

It is almost certain that the greater part of the rainfall of the Folkestone Beds in the Darent valley passes underground, and on the east of Sevenoaks nearly all of the Lower Greensand rainfall

* By Capt. Vetch; quoted in Hughes' *Treatise on Waterworks*, p. 45.

goes the same way. There are here no strong springs within the Darent valley;* so that two-thirds of the rainfall over about 11 sq. miles may be considered as passing northwards beneath the Gault.

Immediately east of the Darent Basin there is the valley of Plaxtole, reaching down to the Atherfield Clay, and carrying away a large quantity of Lower Greensand water. Still further east there are some strong springs about Mereworth, and all down the Medway from Wateringbury to Maidstone. On the north there are some very strong springs about Bradbourn † and St. Leonards, whilst the stream which runs on the north of Offham and West Malling carries off a good deal of water from the Lower Greensand. This stream runs nearly along the anticlinal line described on p. 234.

Although the springs here mentioned carry off a considerable quantity of water from the Lower Greensand west of the Medway, yet the area occupied by that formation is so great (over 40 sq. miles) that there must be a very large amount absorbed by the rocks, and which passes northwards below the Gault.

On the east of the Medway the case is different. There are, as before, the springs all along the river bank, and in addition to this drain of water there is the stream running through Loose, which for the quantity of water carried down is one of the most remarkable in the south-east of England. It falls 180 ft. in 2 miles, from Loose to the Medway; and in that short distance it turns 12 mills.‡

Further north there is the anticlinal line running from Maidstone eastwards, through and beyond Caring Street. This brings up the Atherfield Clay in the valley, down which there runs a considerable stream (the Len). There are but few springs along the Lower Greensand escarpment west of Chart Sutton; but on the east of that place the beds near the escarpment roll slightly over to the south, and here there are springs feeding brooks which flow into the Beult. These springs at the escarpment are not of much avail in draining so large an area of Greensand. But those along the Medway and in the valleys of Loose and the Len are certainly

* There is no trace of any line of disturbance here, and no valley now carrying a stream in the Lower Greensand. Dr. Fitton supposed the disturbance on the west would affect this district (*Trans. Geol. Soc.*, ser. 2. vol. iv. p. 135); but his reason for supposing this appears to be only the existence of high ground near Seal and Ightham. Mr. Hopkins was also far too much disposed to attribute high ground to disturbances.

† Evident from the name; a broad burn or brook. The word "bourn" does not now in Kent or Surrey always mean a brook, but generally an intermittent stream. One such near Croydon is known as "The Bourne;" others in Kent are called "Nailbourns." They are called "Bourns" or "Winterbourns" in Hants and to the west. The term "Levant" is also used in Hampshire and West Sussex. In Yorkshire they are called "Gypseys."

‡ "Topography of Maidstone and its Environs," 1839, p. 85. See Mr. Bland's paper, "Observations on the Rise and Fall of Water in Wells, in the County of Kent," (*Phil. Mag.*, vol. xi. p. 92., 1832), for much information as to the wells in a line from Sittingbourn to Goudhurst, through Boxley, Loose, and Linton.

of very great importance; and the quantity of water carried daily by them into the Medway must be very large.

Possibly, however, what water passes under the Gault on the east of the Medway is not of much avail for the supply of London. It will run to the north-east towards the mouth of the Medway and the Isle of Sheppey. This will certainly be the case with the fourth area, that of Ashford; we therefore need not stay to describe this.

I think it must be evident from the foregoing statements that the amount of water passing northwards below the Gault from the Lower Greensand of Kent and Surrey has been considerably overrated. Yet, when all possible deductions are made, there will probably remain a large quantity of the rainfall unaccounted for. This will doubtless pass northwards, and *may* be available for the supply of deep wells. But this is by no means certain. It is known that an underground ridge of old rocks exists near London, and that the Lower Greensand must thin away along the flanks of this ridge, just as it is actually seen to do in the north-eastern part of the Lower Boulonnais. If there were everywhere an impervious coating of clay surrounding this Palæozoic ridge, then the Lower Greensand would be fully charged with water, which would rise in the wells. But we have no reason to think that such is the case; rather, from what is known, we may expect the permeable beds of the Lower Greensand to lie immediately on the old rocks.

The wells at Kentish Town and Harwich, which reached these rocks, both failed to afford a supply of water. That at Calais, which may have gone through a little Lower Greensand, ended in Carboniferous rocks, and was equally unsuccessful.

The following tables are extracted from the Appendix to the Sixth Report of the Rivers Pollution Commission. The Analyses are by Dr. E. Frankland.

Results of Analysis expressed in Parts per 100,000.

—	Depth (if a Well).	Temperature (Centigrade).	Dissolved Matters.											Remarks.
			Total Solid Impurity.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total combined Nitrogen.	Previous sewage or Animal Contamination.	Chlorine.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.	
I.—Surface Waters from Cultivated Land.														
The Wey, above Godalming. April 21, 1868.	—	—	14·83	·538	·065	·001	·079	·145	480	1·42	·3	8·0	8·3	Clear. Slightly greenish yellow.
The Wey, at Junction with the Thames. October 28, 1868.	—	—	18·10	·307	·077	·005	·090	·171	620	1·83	4·0	6·1	10·1	
The Mole, one mile above Junction with Thames. May 4, 1868.	—	—	23·51	·166	·022	0	·231	·235	1,990	1·78	11·7	4·4	16·1	Turbid. Yellowish.

Results of Analysis expressed in Parts per 100,000—*cont.*

—	Depth (if a Well).	Temperature (Centigrade).	Dissolved Matters.											Remarks.
			Total Solid Impurity.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total combined Nitrogen.	Previous sewage or Animal Contamination.	Chlorine.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.	
I.—Surface Waters from Cultivated Land—*cont.*														
The Mole, at Ditton Bridge. January 31, 1873.	—	—	25·00	·236	·042	·007	·328	·376	3,020	1·90	11·3	5·6	16·9	Turbid.
The Medway. Water supplied to Tunbridge. February 21, 1873.	—	—	15·08	·207	·052	·009	·180	·239	1,550	2·40	1·0	7·0	8·0	Do.
II.—Shallow Well Waters.														
Pepper Harrow, Surrey. Old well at Rectory, (Lower Greensand). August 1869.	—	—	71·40	·014	·012	·001	6·722	6·735	66,910	14·30	3·2	19·2	22·4	
Staplehurst. Well at Toronto House (Weald Clay). September 12, 1872.	—	—	381·10	·202	·048	·160	·064	·244	1,640	82·50	8·0	4·0	12·0	Bad odour. Turbid.
III.—Unpolluted Deep Well Waters.														
Tunbridge. Wells at waterworks. February 21, 1873.	—	9·6	34·76	·036	·006	0	·501	·507	4,690	2·90	15·1	7·0	22·1	Clear and palatable.
Ashford. Well at waterworks. (Lower Greensand). April 1870.	—	—	40·00	·085	·015	·002	0	·017	0	2·80	27·8	6·4	34·2	Slightly turbid; palatable.
Ashford. Water supply from No. 2 Henwood well (Lower Greensand). February 28, 1873.	21	11·3	36·32	·063	·010	·004	·008	·021	0	2·80	19·2	7·7	26·9	Do.
Brighton. Well at workhouse school (reaches Lower Greensand). January 18, 1873.	1,285	9·9	35·36	·078	·007	0	·068	·075	360	8·4	3·2	1·2	4·4	Clear and palatable.
Eastbourn. Well at waterworks. February 22, 1873.	100	10·0	43·12	·058	·010	·004	·130	·143	1,010	10·0	13·8	7·1	20·9	Slightly turbid; palatable.
Folkestone. Waterworks well, No. 3* (reaches Lower Greensand). August 9, 1873.	43	11·5	41·14	·001	·021	·004	0	·024	0	4·20	24·6	7·0	31·6	Clear and palatable.
Brighton. Waterworks† Goldstone Bottom well (Chalk). January 18, 1873.	160	9·6	30·24	·048	·009	0	·644	·653	6,120	3·10	14·8	6·4	21·2	Do.
Dover. Well at waterworks (Chalk). March 1, 1873.	220	11·3	29·6	·034	·008	·001	·452	·461	4,210	2·60	18·6	5·0	23·6	Do.
Caterham Waterworks well (Chalk). February 14, 1873.	490	11·2	27·68	·028	·009	0	·021	·030	0	1·55	15·2	6·0	21·2	Do.

* The water from wells No. 2 and 4 differed but little from this.
† The water from the well in the Lewes Road differed but little from this.

Results of Analysis expressed in Parts per 100,000—*cont.*

—	Depth (if a Well).	Temperature (Centigrade).	Dissolved Matters.											Remarks.
			Total Solid Impurity.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total combined Nitrogen.	Previous sewage or Animal Contamination.	Chlorine.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.	
IV.—Unpolluted Spring Waters.														
Hastings. Dr. Maccabe's spring (Hastings Beds). February 21, 1873.	—	10·0	14·92	·024	·005	0	·433	·438	4,010	4·70	·3	5·7	6·0	Clear and palatable.
Pembury. (Hastings Beds). July 7, 1870.	—	—	12·26	·002	·004	0	·496	·500	4,640	2·83	0	3·3	3·3	Do.
Hindhead. Spring on north side of Gibbet Hill (Hythe Beds). March 7, 1873.	—	9·2	10·02	·032	·004	0	·196	·200	1,640	3·10	0	3·2	3·2	Do.
Sandgate. Spring at Honeywood (Lower Greensand). February 28, 1873.	—	12·0	46·74	·057	·007	0	·358	·365	3,260	5·20	20·8	8·9	29·7	Do.
Sevenoaks. Spring in railway tunnel (Hythe Beds). February 21, 1873.	—	9·0	34·36	·015	·002	0	·416	·418	3,840	2·10	13·7	5·7	19·4	Slightly turbid; palatable.
Whitley, [?Witley] Surrey. Spring at Vicarage Whitley Park (?Hythe Beds). March 7, 1873.	—	11·1	8·80	·031	·008	·001	·635	·644	6,040	2·20	0	3·5	3·5	Clear and palatable.
St. Leonard's near Maidstone (Lower Greensand), spring. August 8, 1873.	—	10·2	29·72	·034	·007	0	·151	·158	1,190	2·20	20·07	3·5	24·2	Do.
Eastbourn. Spring above the town (Chalk). February 22, 1873.	—	10·3	36·46	·070	·011	·001	·736	·748	7,050	3·90	24·2	7·7	31·9	Do.
Folkestone. Springs at Cherry Gardens (Chalk). February 28, 1873.	—	11·0	32·14	·025	·004	0	·313	·317	2,810	2·90	21·3	5·0	26·3	Do.
Lewes. The cockshoot stream from adjacent springs (Chalk). February 22, 1873.	—	8·8	29·80	·087	·023	·002	·513	·538	4,830	2·50	18·1	4·6	22·7	Slightly turbid; palatable.
V.—Polluted Spring Waters.														
St. Leonards-on-sea. Spring in railway tunnel (Hastings Beds). February 21, 1873.	—	—	41·92	·224	·054	·088	·478	·604	5,180	9·60	4·0	12·9	16·9	Turbid; palatable.
Sandgate. Camp Road springs (Lower Greensand). February 28, 1873.	—	10·8	36·90	·146	·030	·001	·955	·986	9,240	5·95	6·9	9·7	16·6	Clear and palatable.
Maidstone. Springs supplying the town (?Chalk). August 8, 1873.	—	—	39·16	·165	·154	·004	·870	1·027	8,410	3·50	20·8	7·1	27·9	Slightly turbid; palatable.
Caterham. The Bourne, under railway bridge in Norden Park (Chalk). February 14, 1873.	—	7·1	32·84	·103	·032	0	·707	·739	6,750	2·40	18·4	7·3	25·7	Turbid; palatable.
Caterham. The Bourne springs, half-a-mile lower. February 14, 1873.	—	8·9	27·26	·138	·029	0	·667	·696	6,350	1·40	15·9	5·6	21·5	Do.

The rainfall of a district is greatly dependent upon its physical geography, and therefore we should expect to find very great differences in the amount of rain falling over so varied a district as the Weald.

There is a high rainfall, exceeding 30 in., over the central high lands of the Weald; and this excessive fall is continued to the west, over the Lower Greensand area of Woolmer Forest, &c., to Selbourne. The fall at Selbourne (34½ in.), is rather larger than one would expect from its sheltered position, lying at the foot of the Chalk escarpment. GILBERT WHITE* remarks that thunderstorms are rare under the Downs at Selbourne; those that come from the south are hardly ever known to reach the village.

I am indebted to the kindness of MR. G. J. SYMONS for the following tables of rainfall:—

MEAN ANNUAL RAIN during Ten Years ending 31 December 1869.

Aldershot	27·04	Hythe (Horton Park)	32·68
Arundel (Dale Park)	33·73	Maidstone (Linton Park)	27·56
Chichester	29·03	Maresfield	31·48
„ (Chilgrove)	33·22	Petersfield (Lyss)	38·03
„ (West Dean)	37·08	Selbourne	34·43
Crpydon	26·33	Tunbridge	28·26
Hastings (High Wickham)	†26·37	Wimbledon	23·48

MEAN MONTHLY RAINFALL during the same period.

Months.	Aldershot.	Dale Park.	Wimbledon.
January	2·992	3·543	1·999
February	1·824	1·846	1·382
March	2·213	2·468	1·716
April	1·531	1·337	1 264
May	2·042	2·639	2 192
June	2·219	2·590	2·452
July	1·887	2·395	1·849
August	2·437	2·936	2·350
September	2·732	3·749	2·286
October	2·561	4·542	2·281
November	2·215	2·535	1·974
December	2·383	3·152	1·731
	27·036	33·732	23·476

* *Nat. Hist. of Selborne*, Letter cx.

† This is rather a small rainfall for the coast. The general amount here is probably 28 or 30 inches.—W.T.

CHAPTER XXII.—BUILDING STONES.

Wealden Sandstones.—The sandstones of the Hastings Beds are very largely employed for building purposes. They are used chiefly in the Wealden district itself, comparatively small quantities being sent to any distance. The sandstone often occurs in blocks of considerable size. When carefully selected it appears to be of average durability; many old churches, castles, and abbeys which are built of it being in a fair state of preservation. It has generally a rather warm tint, and gives a more pleasing effect when in ruins than any other stone in the district.

The weight of a cubic foot of stone from the Calverley Quarry, Tunbridge Wells, was found to be 118 lbs.,* which is equivalent to about 16½ cubic feet to the ton. This is a lower specific gravity than any of the building-stones given in the table on p. 369, but is higher than Hassock and Firestone. Its composition is:—

Silica	94·0
Peroxide of iron	2·5
Carbonate of Magnesia	2·0
Alumina	1·5
	100·0

Rock-sand is occasionally worked; but this is generally obtained by *sawing* the stone into rectangular blocks. The comparatively few joints in the beds enable this to be done in almost any direction. The blocks are soft when first sawn, but the surface hardens by exposure. As this hardening does not extend far from the surface the stone would probably not bear any great crushing weight, and would therefore not do for ordinary building-purposes.

Over the greater part of the Hastings Beds area the Calcareous Grit, or "Tilgate Stone," occurs, chiefly in irregular lenticular masses, and is therefore suited only for road-stone or rough building. In the western districts, however, this kind of stone occurs in more regular beds and is then much quarried. This is especially the case with the more sandy varieties such as the "Horsham Stone," which is a calcareous sandstone, and not in any sense a limestone.

The more flaggy varieties of the Horsham Stone are much used for pavement and slating; these are sometimes known as "healing stone."†

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* Report on Stone for Houses of Parliament.

† "Heal, V. (*Hœlan*, Sax.) To cover with bed-clothes, to cover seed." COOPER'S *Sussex Glossary*. The word is still used in the Weald in the general sense of "to cover."

Of the stone in the Weald Clay proper there is very little that can be used for building. The sand-beds are generally either soft sands or thinly-bedded sandstones.

Sussex Marble (see Chap. VIII.) — The chief building-stone of the Weald Clay, and which was once very largely used, is the "Sussex" or "Bethersden Marble," which contains the large *Paludina*. It is now only dug for roads, but was used in some quantities for the foundations of the Earlswood Asylum. It has been much used in churches in the Wealden district of Kent, especially in towers of the *Perpendicular* style; Headcorn, Smarden, Biddenden, and Tenterden, are good examples. The polished altar-stairs in Canterbury Cathedral are of this stone.

The small Paludina limestone seems to have been less commonly used in architecture, and I think it likely that in many cases where "Sussex Marble" is mentioned in descriptions of churches, Purbeck Marble may be meant. It is not always easy to distinguish the latter from the small Paludina limestone. MR. DREW was inclined to think that the Bethersden Marble, as a building-stone, came into use with the Perpendicular style; and there seems some ground for this belief, as regards the churches in the Weald of Kent.* Purbeck Marble on the other hand is highly characteristic of the Early English style, and of late Transition Norman.

In domestic architecture the Wealden marbles were chiefly used, polished, for mantel-pieces; these still remain in many of the older houses. Limestone containing the smaller Paludina was often used for this purpose.

Kentish Rag (see pp. 116–120). — The mode of occurrence, thickness, &c. of these beds have been already sufficiently described, I will here only note some particulars of economic interest. The chief value of the Rag is its fitness for building; large quantities are shipped for this purpose from the Maidstone district.†

Its composition may be generally represented by the following analysis, by MR. R. PHILLIPS:—

Carbonate of lime	92·6
Earthy matter	6·5
Oxide of iron	0·5
Carbonaceous matter	0·4
	100·0

Its weight is about 13 cubic feet to the ton. This analysis is that of a tolerably pure limestone, but some varieties of rag are much more siliceous in character.

The value of Kentish Rag as a building material will be apparent from the following table, which I have compiled from several given

* In the remains of the Early English crypt of Waverley Abbey, near Farnham, the shafts of the pillars appear to be of Purbeck Marble, whilst the capitals are of Sussex Marble.

† Amounting, in 1858, to 55,000 tons annually.—*Mineral Statistics for* 1858, Part II. p. 176.

by MAJOR-GEN. SIR C. W. PASLEY, as the results of his experiments* :—

COMPARATIVE STRENGTH of BUILDING STONES, BRICKS, and CHALK.

Description of Stones, &c.	Weight per Cubic Foot in lbs.	Cohesiveness in lbs.	Adhesiveness in lbs.	Resistance in lbs.
Kentish Rag Stone -	165·69†	3,773	1,495	4,581
Bricks - - -	91·71	—	1,359	752
Bath Stone - -	122·58	1,404	1,103	666
Cornish Granite - -	172·24	3,841	900	2,808
Portland Stone - -	148·08	4,004	856	2,887
Craig Leith Stone -	144·77	2,439	855	1,896
Yorkshire Landing Stone	147·67	3,642	823	2,887
Chalk - - -	94·99	473	—	334

The harder beds of "Hassock" (or "Calkstone") are often used for building-purposes. In the Iguanodon Quarry, near Maidstone, there are some layers of it, which somewhat resemble Portland Stone. MR. BENSTED informed me that some of the interior of Westminster Abbey is built of this stone.

The following analysis of Hassock is by DR. PLOMLEY of Maidstone (weight, 19 cubic feet to the ton):—

Carbonate of lime - - -	- 53·0
Alumina - - - -	- 4·0
Oxide of iron - - - -	- 8·0
Silica - - - - -	- 32·0
	97·0

with small quantities of phosphate of lime, soda, magnesia, chlorine, and sulphuric acid.

Calcareous tufa occurs at East Malling, lying about in the fields; it is no doubt derived from the Kentish Rag. There is no section showing it now, but I am told that it runs in a line from the Rectory westwards. It has been dug in some quantity at one time, as large masses are built into the walls of East Malling Church, and it has been much used in St. Leonard's Tower.

This tower is *early* Norman; distinct traces of "herring-bone" work may be seen in the inside walls. The arches are constructed with tufa, whilst in later and more finished Norman work (as the keep at Rochester Castle), Caen stone is used for this purpose. Tufa is also used at the corners of the tower and inside the staircase at the N.W. corner.

Bargate Stone (see pp. 122–124) is a building-material of some value in the district where it occurs, viz., in the neighbourhood of Godalming; but it is not of uniform quality. "The stone varies considerably in the same quarry. Sometimes it is a hard

* *Observations on Limes, Calcareous Cements*, ... 2nd ed., 1847, pp. 121, 127, 142.

† Equal to 13·52 cubic feet to the ton.

and compact limestone of a greyish colour, scarcely to be distinguished from the better sort of Kentish Rag, and containing as much as 70 per cent. of lime. At other times it is loose and rubbly, containing much argillaceous matter, and frequently towards the lower part it consists of a conglomerate of coarse sand and pebbles, held together by a strong calcareous cement."*

Pulborough Stone (see pp. 125–6).—The sandstones of the lower part of the Hythe Beds are a good deal worked at the western end of the Weald. Generally they are rather soft, but near Petworth and Pulborough they form excellent building-stone. "They have been extensively worked at Pulborough for several years, and were used by the Romans for building-stone. Pulborough Church was built of this stone in the 16th century. Arundel Castle [the keep] and Town Hall, as also the piers at Littlehampton."†

It is only in the neighbourhood of Nutfield that the Sandgate Beds yield building-stone of any value. Here, associated with the fuller's earth there are some very good bands of stone (see pp. 130–133).

Folkestone Stone (see p. 138).—It is only near Folkestone and for a few miles west of that town that the highest division of the Lower Greensand yields much building-stone. Here it is a calcareous sandstone, often concreted along the lines of false-bedding. This rock is not very largely dug, and is generally much less durable than the Kentish Rag.

Carstone (see pp. 140–144).—This, the hardest and most durable stone in the district, is only used in building for walling, rough pavement, and, in some places, for the purpose described by GILBERT WHITE in the following extract:—

"In *Wolmer Forest* I see but one sort of stone, called by the workmen *sand*, or *forest stone*. This is generally of the colour of rusty iron, and might probably be worked as iron ore [?]; is very hard and heavy, and of a firm, compact texture, and composed of a small roundish crystalline grit, cemented together by a brown, terrene, ferruginous matter; will not cut without difficulty, nor easily strike fire with steel. Being often found in broad flat pieces it makes good pavement for paths about houses, never becoming slippery in frost or rain. In many parts of that waste it lies scattered on the surface of the ground; but is dug on *Weaver's* Down, a vast hill on the eastern verge of that forest, where the pits are shallow, and the stratum thin. This stone is imperishable.

"From a notion of rendering their work the more elegant, and giving it a finish, masons chip this stone into small fragments about the size of the head of a large nail; and then stick the pieces into the wet mortar along the joints of their freestone walls; this embellishment carries an odd appearance, and has occasioned

* MEYER. The Lower Greensand of Godalming. *Geol. Assoc.* 1868, p. 16.
† Cat. of Rock Specimens in the Museum of Practical Geology, 3rd ed. p. 153.

strangers sometimes to ask us pleasantly 'whether we fastened our walls together with tenpenny nails?'"*

Upper Greensand. (Malm Rock, Firestone, Chert, and Rag, see pp. 153–159).

To the east of Westerham there are no hard beds available for building in the Upper Greensand; but to the west of that town, and from thence round the Weald to near the Brighton railway on the south, there are such; and again near Eastbourn.

The best known rock from this division is the "firestone," which has long been quarried in the neighbourhood of Gatton, Merstham, and Godstone. It is a calcareous sandstone, varying much in hardness, containing scattered green particles and micaceous scales. The beds known as "Malm Rock" in West Surrey, Hants, and Sussex, are very similar in character.

This stone is generally very soft when freshly dug, but hardens by being kept under cover. It is said to have been used at Hampton Court and Windsor Castle.

This stone is not very durable. MR. C. H. SMITH states that it was brought in former days from Reigate and Godstone, for the construction of the principal buildings in London. Of these buildings there are now scarcely any parts remaining; some of the upper portions of Westminster Abbey, about the cloisters, and the interior parts in Dean's Yard, are the only relics. SIR CHRISTOPHER WREN, speaking of Westminster Abbey in his day, described it as having mouldered away four inches from its original surface.†

In the "Report on the Selection of Stone for building the New Houses of Parliament" 1839, the firestone of Gatton Quarries is described as a "sandstone" consisting of "fine siliceous grains with a calcareo-siliceous cement, containing green silicate of iron and plates of mica." The weight of the stone in its ordinary state is 103 lbs. per cubic foot, or 21¾ cubic feet to the ton.

No complete analysis of the rock in this district has been made,‡ but that near Farnham has been analysed by PROF. WAY (see p. 391).

GILBERT WHITE thus describes the uses of the firestone of Hants§:—

"This stone is in great request for hearth-stones, and the beds of ovens; and in lining of lime-kilns it turns to good account, for the workmen use sandy loam instead of mortar, the sand of which fluxes, and runs by the intense heat, and so cases over the whole face of the kiln with a strong vitrified coat like glass, that it is well preserved from injuries of weather, and endures 30 or 40 years. When chiselled smooth it makes elegant fronts for houses, equal in colour and grain to the Bath stone, and superior in one

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* WHITE'S *Nat. Hist. of Selbourne*, Letter iv. 4to., 1789.

† *Proc. Geol. Assoc.*, vol. i. p. 210, 1862.

‡ A piece of firestone rock, from Merstham in Surrey, was found to contain 40 per cent. of soluble silica. WAY and PAINE. *J. R. Agric. Soc.*, vol. xiv. p. 235.

§ Letter iv.

respect, that, when seasoned it does not scale. Decent chimney pieces are worked from it, of much closer and finer grain than Portland; and rooms are floored with it; but it proves rather too soft for this purpose. It is a freestone, cutting in all directions; yet has something of a grain parallel with the horizon, and therefore should not be surbedded [set on end], but laid in the same position that it grows in the quarry. On the ground abroad this firestone will not succeed for pavements, because probably some degree of saltness prevailing within it, the rain tears the slabs to pieces. Though this stone is too hard to be acted on by vinegar, yet both the white part, and even the blue rag, ferment strongly in mineral acids. Though the white stone will not bear wet, yet in every quarry, at intervals, there are thin strata of blue rag, which resist rain and frost, and are excellent for pitching of stables, paths, and courts, and for building of dry walls against banks, a valuable species of fencing, much in use in this village, and for mending of roads. This rag is rugged and stubborn, and will not hew to a smooth face, but is very durable. . ."

The "blue rag" mentioned in the foregoing paragraph is a rather siliceous limestone, scarcely distinguishable from some kinds of Kentish Rag. It is seldom found in thick enough beds to serve well for building purposes. Sometimes this rag passes into a very cherty stone, and is then harder, and has a more splintery fracture.

The thinner and softer beds of firestone are broken into irregularly-shaped fragments, and are then sold for rubbing hearths. They are known as "Hearthstones."

The Malm rock has been used in the Roman Villa at Bignor, not only for ordinary masonry, but also, polished, in the fountain (?) which is in the centre of the largest room. In this form it makes an excellent marble, which I have not elsewhere seen employed.

At Eastbourn, beds of greenish sandstone are quarried for building; Pevensey Castle is partly built of this. The catapult balls which have been found here are made of the same stone.

Elsewhere is given an account of the agricultural value of the siliceous rock in the Upper Greensand, which is remarkable for containing a large per centage of soluble silica, or silica soluble in caustic alkali. (*See* pp. 262 and 390.)

Mr. F. Ransome has more recently experimented upon this siliceous rock from Farnham, and has succeeded in producing a new artificial stone, called "Apœnite." The process is thus described by Mr. Ransome*:—"He combines a portion of the Farnham stone, or soluble silica, with a solution of silicate of soda or potash, lime (or substances containing lime), sand, alumina, chalk, or other convenient and suitable materials, which, when intimately mixed, are moulded into the required form as heretofore, and allowed to harden gradually as silicate of lime

* On some Recent Improvements in the Manufacture of Artificial Stone, and the Application of such Stone to Construction and other Purposes." *Rep. Brit. Assoc. for* 1872, Trans. Sect., p. 248.

is formed by the combination of the ingredients present. The mass then becomes thoroughly indurated and converted into a compact stone, capable of sustaining extraordinary pressure, and increasing in hardness with age.

"The chemical actions which effect these results appear to be as under. When the materials are mixed together, the silicate of soda is decomposed, the silicic acid being liberated combines with the lime and forms a compound silicate of lime and alumina, while a portion of soda in a caustic condition is set free. This caustic soda immediately seizes upon the soluble silica (from Farnham), which constitutes one of the ingredients, and thus forms a fresh supply of silicate of soda, which is in its turn decomposed by a further quantity of lime, and so on.

"If each decomposition of silicate of soda resulted in the setting free of the whole of the caustic soda, these decomposing processes would go on as long as there was any soluble silica present with which the caustic soda could combine, or until there ceased to be any uncombined lime to decompose the silicate of soda produced, the termination of the action being marked by the presence in the pores of the stone of the excess of caustic soda in the one case, or of silicate of soda in the other. In reality, however, the whole of the caustic soda does not appear to be set free each time the silicate of soda is decomposed by the lime, there appearing to be formed a compound silicate of lime and soda, whereby a small portion of the latter is fixed at each decomposition. The result is that the caustic soda is gradually fixed, and none remains to be removed by washing or the other process.

"At the age of 10 weeks, in stones made by this process, the strength as compared with Portland stone was found to be as 7145 lbs. to 2630 lbs. per square inch, and as compared with Bramley Fell 7145 lbs. to 5120 lbs., and as regards Granite 7145 lbs. to 1200 lbs. per square inch. With reference to durability, it has been found practically to withstand the atmospheric changes of various climates, having been exposed to the cold of Russia and the heat and rains of India. In general appearance it bears such a perfect resemblance to the best description of natural stones as to mislead the most critical observers, whilst the facility of application and its economy in use will have been apparent from the foregoing description."

Chalk has been used as a building-stone both for outside and inside works, in Surrey and Sussex. "Chalk was used probably before the Norman Conquest, for the filling in of thick walls, and also occasionally for inside vaulting, of which specimens may be seen in Canterbury and Rochester. It is still used in some parts of Norfolk for the walls of cottages, or for enclosures, but not for any buildings of importance."*

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* Pasley, p. 143. This writer states that many artificial stones are "inferior in strength to common chalk in its dry state, which has been rejected for many centuries as being unfit for the purposes of building."

Chalk has been used in the Lower Boulonnais in church architecture. The church of Neufchatel is apparently wholly built of this. The finest example which I know, of the use of Chalk as a building stone, is in Amiens Cathedral. The mouldings and pillars are worked in Chalk-with-flint. The flints have not been removed, but were chiselled through, just in the same way as the surrounding Chalk. The work is still in perfect preservation.*

The French Chalk is naturally harder than that of England, a circumstance that may account for the preservation of the so-called "Needles" in the valley of the Seine. We have no such things as these in England, along Chalk valleys or escarpments.

Chalk-flints are a good deal used over the Chalk district of Sussex, and also in the country immediately bordering on the Chalk.† They are generally roughly broken; but are sometimes worked into a square face, and in this form, where the work is well executed, they have a very pleasing effect.

The tower of St. Clement's Church, Hastings, is built of stone and dressed flints, in alternate squares, like those of a chess-board. This style is uncommon in the district; the flints here are not very perfectly squared. Some houses at Lewes afford perhaps the best examples of dressed flints.

Near the coast the larger flint pebbles from the shingle are used for building. Many of the older houses in Brighton are built of this material.

There is another use to which flint-shingle is put, which may be worth noting here. It is made into an artificial stone or concrete, by being mixed with cement and cast in moulds. The sea-wall defending the Redoubt at Eastbourn is made of such blocks. Here they measure 4 ft. × 3 ft. × 2 ft., and are nearly, but not quite, rectangular, so that the wall when completed has a curved outline. Large quantities of such blocks were made at Rye for the Admiralty pier at Dover.

A somewhat similar method is occasionally employed for building the walls of huts and small cottages. A wooden frame is run up of the size of the required wall, and into this the shingle and mortar is poured. When the concrete is consolidated the mould is removed and the wall is complete.

It may be useful to give here a list of some public buildings, in or near London, the external work of which has been constructed, wholly or partly, of stone from our district. The date of the

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* This Cathedral, excepting the western front, was finished in 1269. I do not mean that it is wholly or chiefly built of Chalk. The part that struck me was in the triforium gallery; I think near the eastern end.

† Flints have been very largely used for building at Norwich. Galleries have been found driven through the Chalk for a distance of 4,600 feet, from which the flints are supposed to have been got about 300 years ago. (See a note by G. W. FEATHERSTONHAUGH, *Proc. Geol. Soc.*, vol. i. p. 35.)

buildings are given, so that the durability of the stones can be seen by inspecting the buildings. The list is extracted from the "Builder" of 18th Sept. 1858. It was prepared by MR. WYATT PAPWORTH, who says:—"This list is compiled from the descriptions which have appeared in the public prints of the various buildings, and I fully believe it may be relied upon . . . . . The buildings where these stones are employed have been in some instances cleaned down, perhaps more than once; this should be borne in mind when viewing the present state of the stone." The quarries from which the stones were obtained are not given; probably most of the Kentish Rag came from near Maidstone.*

Kentish Rag, and Bath Stone Dressings.

All Saints' Church, Acton-street, Hoxton, 1857.
St. Philip's Church, Arlington-square, Hoxton, 1855–7.
St. Margaret's, or Broadway Chapel, Westminster, 1841–3.
Mansion-house Chapel, Camberwell (? Caen stone), 1852–3.
St. Michael's Church, Chester-square, 1844–6.
Congregational Church, Clapham, 1851–2.
Ealing Church, 1850.
St. Mary's Church, Earl's-court, Brompton (Coombe-down Bath stone dressings and Caen stone parapet and cornice), 1849–51.
Christ Church, Endell-street, St. Giles's, 1844–5.
St. Mary's (R. C.) Church, Farm-street, 1846–9.
All Saints' Church, Finchley New-road, 1845–6.
Trinity Church, Bishop's-road, Bayswater, 1845–6.
St. Matthew's Church, Great Peter-street, Westminster, 1849–51.
St. Stephen's Church, Hammersmith, 1849–50.
St. Mary's Church, Johnson-street, Commercial-road East, 1849–50.
St. John's Church, Notting-hill, 1844–5.
Wesleyan Chapel, Liverpool-road, 1849–50.
St. Helen's (R. C.) Church, Westbourne-grove North (Box-ground Bath stone), 1852–3.

Kentish Rag and Broomhill Stone (Kent) Dressings.

St. Michael's Church, Wood-green, Tottenham, 1843–4.

Kentish Rag and Caen Stone Dressings.

Holy Trinity (R. C.) Church, Brook-green, Hammersmith, 1851–2.
All Saints' Church, Cambridge-place, Paddington, 1850.
New City Prison, Holloway, 1849–52.
St. Barnabas's Church, Pimlico, 1846–9.
St. Alexis (R. C.) Church, Fitzroy-place, Kentish-town, 1849–50.
St. Mark's Church, Rosherville, 1853–4.
Christ Church, Highbury-grove, 1848.
St. Barnabas's Church, Homerton, 1845–7.
Holy Trinity Church, Milton, next Gravesend, 1844.
St. Mark's Church, Old-street-road, 1846–8.
St. Gabriel's Church, Warwick-square, Pimlico, 1852–3.
Chapel to Consumption Hospital, Brompton, 1849–50.

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* Kentish Rag is usually employed in rubble-work, not dressed; but MR. J. G. HILTON informs me that at Ashford Church (Kent) the mouldings and tracery of the windows are in Rag.

Kentish Rag and Corsham Bath Stone Dressings.

All Saints' Church, Blackheath, 1857–8.

Kentish Rag, Hammer-dressed Yorkshire Stone Facing, and Caen Stone Dressings.

St. Giles's Church, Camberwell, 1842–4.

Reigate Stone and Bath Stone.

Asylum for Idiots, Red-hill, 1853–5.

Bargate Stone and Bath Stone Dressings.

Holy Trinity Church, Vauxhall Bridge-road, 1849–52.

CHAPTER XXIII.—ROADS AND ROAD MATERIAL.

As a whole the Wealden area is tolerably well supplied with rocks which serve for road-metal; and, now that railway communication is extended all over the district, there *need* be no lack of suitable stuff in any place. But formerly the case was very different. Then, it was impossible, except at a ruinous expense, to obtain road-metal over much of the central districts; and hence, in all old accounts of the Weald, we are constantly reading most dolorous and amusing complaints of the state of the roads. One might easily fill many pages with extracts illustrating this. WALPOLE often alludes to it in the letters giving an account of his travels, and MACAULAY refers to the Wealden roads as sad examples of the state of inland communication. Perhaps the following are less generally known:—"The roads in the winter season are the worst in England; for many of the prodigious trees which grow here, and are carried through this part of the country in the summer time, to the Medway, on a carriage called a Tug, drawn by twenty oxen, advances so slowly, that it is often several years before the tree reaches the place of its destination, for if ever the rain sets in, it stirs no more for that year, and often the summer is not dry enough to make the roads passable."*

"Knowle is stated to have been given by Queen Elizabeth to the Sackville Family, 'on account of the foul ways in Sussex,' which made access to Buckhurst, their Sussex residence, nearly impracticable in winter. And, so late as the year 1818, Bishop Buckner thought it necessary to advise a gentleman, whom he had ordained in the November of that year, as curate of Waldron, to lose no time in going there; for in the course of a very short time he would find it impossible to do so."†

"In the miry parts of the Weald of Kent,—and the same statement doubtless would apply to similar portions of Sussex,—wheel carriages were not generally, because they could not be, used, except on the principal lines of road, until a very recent period. Long within my own recollection the cross roads in some districts of Kent were utterly impassable during the winter; and, as I have witnessed, if a miller, for example, wished to deliver goods down one of these lanes, he would exchange his horse's harness

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* *England Displayed; Travels by a Society of Gentlemen*, Edited by P. RUSSELL, vol. i. p. 116, 1769. Bad as the roads undoubtedly were, this description is surely overdrawn; as is probably the following also:—"There is such an instance of the benefit of a turnpike-road at Horsham, as is very rarely to be met with: the present road to London was made in 1756; before that time it was so execrably bad, that whoever went on wheels, were forced to go round by Canterbury." REV. A. YOUNG, *Agriculture of Sussex*, p. 418, of ed. 1808.

† REV. E. TURNER, *Sussex Arch. Coll.*, vol. xxx. p. 153. See also a paper by MR. BLENCOWE in vol. xvi. p. 305.

for a packsaddle, and, leaving his cart by the side of the turnpike road, he would load the saddle with his flour-sacks and himself,—thus resorting to the same mode of conveyance used for ages previously. The tracks, for such alone were many of those bye lanes, which occasionally were wide and overgrown with grass, were provided with a narrow sort of causeway, sometimes perhaps with two paths, one being paved with irregular-sized slabs of stone, the other covered with small stones; the first for foot passengers, the second for horses. Upon such as the latter I myself have ridden formerly, though few, if any, it is probable, now remain. Of the paved causeways numerous examples may still be seen on the borders of the roads in some parts of Kent."*

These causeways in the Weald Clay districts are made of Paludina Marble; in the clay districts of the Hastings Beds Calcareous Grit from the Wadhurst Clay is used; and in the western parts of the Weald slabs of Horsham Stone.

There is a very common practice throughout the Weald which well illustrates the condition of the roads. Outside the houses there are birch-brooms staked into the ground, which serve as scrubbers for taking some of the clay off the boots. I do not know that this practice is peculiar to the Weald, but in the south-east of England it is especially characteristic of that district.

Many of the farm-roads are still "mended" in the most primitive manner, with bushes and small bougns of trees, laid in the ruts.† The worst examples of roads are of course on the clay districts; but the Wealden sands and sandstone are generally exceedingly fine in grain, and often contain a good deal of loam, so that they have, when wet, a very clayey look and character.

The heavy traffic to and from the ironworks seems to have done considerable damage to roads never very good. To counteract this evil an act was passed in the 27th of ELIZABETH, which provides that "the occupiers of all maner of iron works whatsoever . . . . which shall at any time hereafter carrie or cause to be carried anie coles, mine, or iron, to or for anie their iron works, betweene the twelfe daie of October, and the first daie of Maie yeerelie" shall for every six loads of coal or mine, or for every ton of iron so carried, "cause also to be carried yeerelie by the space of one mile through anie high waies, being under anie the hils commonlie called the North downs of Surrie and Kent . . . one usual cart load sindar, gravell, stone, sand, or chalk, meet for the

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* REV. A. HUSSEY, *Notes on the Churches in the Counties of Kent, Sussex, and Surrey*, 1852, p. 1. This practice is very old. DR. HATLEY in describing, in 1684, some shell-marble found at HUNTON, says it is "much like that coarse sort of marble-stone which is dug about Pluckley in the Wild of Kent.....with this stone they make their Causeys in that part of the country." *Phil. Trans.*, vol. xiv. p. 464.

† I have somewhere read of these roads being *mended with the plough*, the mire being turned up on the side to dry, whilst a new bottom is meanwhile obtained. I have not myself seen this interesting performance.

repairing and amending of the said high waies." This act (or so much of it as referred to highways) was repealed in the 39th of ELIZABETH, and it was further enacted, that for every three loads of coal or mine, and for every ton of iron carried one mile between the months of October and May, 3*s.* should be paid, whilst during the summer months for every thirty loads of coal or mine and for every ten tons of iron, the same sum should be paid or one ton of road material provided.

Of the road materials within the Weald itself, one of the best is the slag or "cinder" from the old ironworks. This makes a dark brown road.

A sandy ironstone is often dug over the Hastings Beds, which also makes a brown or reddish road. This becomes oxidised, and decomposes at the surface and along the joints into a dark brown soft stone, whilst the interior is harder and lighter in colour; hence it is often known as "Kernel Stone." Somewhat similar stuff is dug in places about Ashdown Forest, and is there called "Crowborough Stone." Clay-ironstone is sometimes used, but more rarely.

The calcareous sandstone (Tilgate Stone) of the Wadhurst Clay is much sought after. Near Hastings it is called "Hastings Granite." Large quantities are dug at Beech Green, near Penshurst; and there it is known as "Beech Green Stone." Horsham stone and similar calcareous stones are also used. The Purbeck limestones are still dug for roads, and so are the Paludina limestones of the Weald Clay. There is a practice called "punching" resorted to in the Weald Clay district of Surrey and the adjoining part of Sussex. Iron rods are used for piercing the clay in search of any hard beds that may serve for roads.

The cemented gravel of the Weald Clay district is often used; it is cemented by iron into a conglomerate. In Kent this sort of stuff is called "Crowstone" or "Crowstoney-gravel;" in Surrey and Sussex it is known as "ragstone" or "iron-rag." The river-gravel of the district is also dug for this purpose, but, being generally made up almost wholly of fragments of Wealden sandstone, it is too soft to be durable. Still worse is the sandstone itself, which is occasionally dug for roads under the name of "gravel."

I believe that this completes the list of road-materials from the Wealden district proper. But another source of road-metal is the shingle, which fringes the whole length of the Wealden coast, with but few interruptions. This, which is known as "Beach," is chiefly got from Rye, and is sent up the Rother, in barges, into the interior of the country. Large quantities are unshipped at Blackwall, Newenden, and Bodyham Bridges. It is also sent up the Brede as far as Brede Bridge.

The country beyond the Weald Clay is well enough supplied with road-metal. The natural foundation of the road is also generally much better here than in the Weald. The Lower Greensand everywhere, except in its eastern range in Sussex, provides a good supply of material; and, failing this, there are always Chalk-flints not far off.

Flints are quite useless for road-mending when freshly got out of the Chalk. They are always allowed to lay for two or three years to weather; by which means they to some extent lose their extreme brittleness, and become tougher. The flints best suited for this purpose are those dug out of the long dry-valleys of the Chalk, or those picked off the fields. This last process, strange as it may seem, is ruinous to the soil. The flints from river-gravels are very good.

One of the best road-materials is the "Carstone" from the Folkestone Beds: this is everywhere dug for the purpose. Kentish Rag and Bargate Stone are also largely used, especially the former. The Upper Greensand also affords rag and some chert.

The chert of the Hythe Beds is a very serviceable stone. It occurs in some quantity on the west of the Medway, and, under the name of "gravel," is dug in many places over Great Comp and Mereworth Woods. Further west it is called "Sevenoaks Stone;" near Leith Hill it is (or used to be) called "red flint,"* and in Sussex it is known as "whinstone." The smaller pieces of this chert, when mixed with some of the clay with which it often occurs, "binds" well together, and makes capital garden paths.

From the materials mentioned above we get very different results when they are used as road-stone, whether we regard their durability or the comfort of travellers. The limestones, when used alone, are apt to make a dusty road in summer, and one that is easily disintegrated by frost and thaw in winter.

The flints, whether in their original form as chalk-flints, or worn down into shingle, make after a time a tolerably smooth road, but one that is generally dusty; and in very windy weather the fine gritty dust from such roads is particularly irritating. Chert, being much less brittle, is less liable to wear down into dust.

The most agreeable roads to travel upon are those mended with ferruginous stones; either Carstone, or the Kernel stones, &c. of the Weald; these always give a warm tint, brown or reddish. Many of the undulating Wealden roads that are mended with such stones are very pleasant, particularly when fringed with green swards and wooded hedgerows.

Most of the materials give better results when mixed than when used separately. Flints and rag, or any other limestone, make a better road than when either is used alone.

Of the roads themselves we may add a few particulars. And first, as to the roads upon the Upper Greensand terrace, near Selbourne, as described by GILBERT WHITE (Letter v.):—"Among the singularities of this place, the two rocky hollow lanes, the one to Alton, and the other to the forest [Woolmer Forest] deserve our attention. These roads, running through the malm lands, are by the traffic of ages and the fretting of water, worn down through the first stratum of our freestone, and partly through the second, so that they look more like watercourses than roads, and

* As I am informed by D. D. HEATH, ESQ., of Kitland.

are bedded with naked rag for furlongs together. In many places they are reduced sixteen or eighteen feet beneath the level of the fields . . . . . ."

These deep lanes were not originally watercourses, but have become so by being worn deeply down below the general level. The denuding effects of water are as plainly seen in them now as in true streams. WHITE, describing a violent storm which occurred in June 1784, says [Letter cx.], "The hollow lane towards Alton was so torn and disordered as not to be passable till mended, rocks being removed that weighed two hundredweight."

Of such hollow lanes there are many other examples. They often occur over the Lower Greensand, and in the rocky lands of the Hastings Beds. Here they are particularly picturesque. The joints of the rock and its top being often covered with foliage. In many cases these roads have been purposely dug out to a certain depth in order to lessen the gradients, but in others, perhaps in most, the hollow ways are wholly worn by long-continued traffic.

There is a Roman road running from Pulborough across the Weald Clay to Dorking, known as the "Stone Street Causeway." This, in part of its course, goes *over* river gravel containing flints; and with the flints from this gravel the road is in great part made. Some writers have described the road as being made of flint shingle brought from the coast, but this appears to be a mistake.* This was the only Roman road that traversed the Weald, but further to the east, running from Pevensey through Wadhurst and Tunbridge Wells to London, there is supposed to have been an older or British Way.† These were probably the only continuous roads, which fairly crossed the Weald, for some centuries after the close of the Roman occupation.

Most of the roads enter the lower country through the transverse valleys of the Chalk, or else through the "passes." Some, however, cross the escarpment where there is no natural break. The main lines of road on the Lower Greensand country run along the strike, sending off branches into the Weald, which generally go straight across the strike.

The lines of railway enter the country by natural depressions in the Chalk escarpments, either by the transverse river valleys or by the passes, where the tunnels can be short. The only exception to this is the new, and as yet unfinished, Surrey and Sussex Line, which cuts the Chalk escarpment near Oxtead; here there is no depression. Most of the railways *cross* the Weald, cutting across the strike of the Lower Greensand and Weald Clay, but necessarily winding to some extent along the strike-valleys of the Hastings Beds.

The South-eastern line is an exception. This from near Redhill to Ashford runs along the Weald Clay in an almost straight line, and with few changes of gradient, and these for the most part are exceedingly gentle. Some of the newer lines of

* As was pointed out by MR. P. J. MARTIN, *Suss. Arch. Coll.*, vol. xi. p. 135.
† R. FURLEY'S *History of the Weald of Kent*, p. 5.

railway run along the strike of the Lower Greensand, connecting the towns which are built on that formation.

There is a remarkable line of road running for many miles beneath the North Downs, which, from its close connexion with the geological features of the district, deserves more particular mention here. It is reputed to be British: but it was no doubt used by the pilgrims journeying to the shrine of ST. THOMAS of CANTERBURY, whence the name by which it is now commonly known:—The Pilgrim's Way or Road.

DR. STANLEY, in describing the approaches to Canterbury, says:* —"Another line of approach was along the old British track which led across the Surrey downs from Southampton; it can still be traced under the name of the Pilgrims-way, or the Pilgrim's-lane, marked often by long lines of Kentish yews,—usually creeping half-way up the hills immediately above the line of cultivation, and under the highest crest, passing here and there a solitary chapel or friendly monastery, but avoiding for the most part the towns and villages and the regular roads."

The course of this road is remarkably distinct in Kent. It can be traced with scarcely a break from the border of Surrey nearly to the coast. It is somewhat remarkable, however, that it does not appear to reach the coast, but ends, as a continuous road, at the Roman Road or Stone Street, which runs from Lympne to Canterbury. On the west it seems to terminate, as a continuous road, exactly on the borders of Surrey. Here there is a road running obliquely up the Chalk escarpment, from the pilgrim's road, past Tatsfield, to Cold Harbour Green; a name which suggests an old line of road. But at the foot of the escarpment, and about a mile west of the county boundary, there is a Pilgrim's Farm (not marked on the one-inch map). Past this, then, the road would probably continue, and still further westwards through Surrey. Here, however, it cannot be traced as a continuous road at the foot of the escarpment, and it probably took to the Lower Greensand tract. MR. ALBERT WAY,† traces its probable course with some minuteness, taking it over St. Martha's and across the Wey at Shalford.

It can be extremely well seen on the north of Sevenoaks, perhaps better here than elsewhere. It crossed the Darent at Otford, where are the ruins of an archbishop's palace. "Abp. Becket supplied it [the site] with water, which, according to the local legend, it wanted until he struck his staff into the ground, thereby calling forth the spring which still feeds St. Thomas's Well, close to the ruins. The saint is also said to have used this spring as a bath. The water is still thought to be of powerful virtue, and is resorted to as a cure for various ailments."‡

The solitariness of this road can better be seen from Otford eastwards, than elsewhere. There is scarcely a house along its

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* *Historical Memorials of Canterbury*, p. 195 of 5th ed., 1857.

† See Appendix to DR. STANLEY'S book. CAPTAIN E. R. JAMES has traced the road in Surrey in his "Notes on the Pilgrims' Way, in West Surrey," 8vo. Lond. 1871.

‡ MURRAY'S *Guide to Kent*, p. 82 of 2nd ed., 1863. The spring comes out at the base of the Chalk.

line, whilst just to the south, and running parallel with it, at a distance of from ¼ to ⅓ of a mile, is the road connecting the villages of Kemsing and Wrotham and the intermediate farms. The parallel road on the south is not continued to the east of Wrotham, but as far east as the Medway the pilgrim's road is as solitary as before. East of the Medway there are more farms along the road, and the villages of Deptling, Hollingbourn, Wye, and Eastwell touch it. In the first two of these, however, the Churches are built below (to the south of) the road, and the villages appear to have grown up to it. Wye and Eastwell are therefore the only villages throughout Kent which are truly on the pilgrim's road; yet through Kent, and in fact all round the border of the Weald, there is a line of villages at the foot of the escarpment. These, where not joined by a direct line of road, have cross-roads going to the main-road, which then passes along the Lower Greensand.

Through Sussex there is no road precisely corresponding to the pilgrim's road, but there is one along the line of villages.

Col. Lane Fox, in his account of the "Hill Forts of Sussex,"* describes the ancient condition of the country, and infers that the transverse Chalk valleys were either wholly occupied by water or were impassable swamps. On the north of the Chalk escarpment there was the great forest. So that this Sussex Chalk was divided into five distinct areas, and the only means of communication between them, except by canoes, must have been along the northern slope of the downs, between the heads of the waters and the forest of Anderida.

"Sufficient traces of an ancient roadway exist to the present day along this northern ridge of hills to prove that this must, in fact, have been the great thoroughfare of the inhabitants in ancient times. At every two or three hundred yards between Ditchling and Lewes the track of an ancient pathway may be seen running obliquely down the hill. In some places a line of road, running east and west, may be distinctly traced about halfway down the hill. . ."

It is rather remarkable that round the Lower Boulonnais there is a road very like the pilgrim's road. It differs, however, from that of Kent, in that the villages and their Churches are for the most part *on* it, or nearly so. Still there is a very marked tendency for the farms and hamlets to keep *below* the road. The road here, as in Kent, runs well on the Chalk, whilst the farms are on the outcrop of the Upper Greensand. The road is very well marked on the south of the Lower Boulonnais, from the termination of the Chalk escarpment at Neufchatel to Desvres. I am not acquainted with the extreme eastern corner of the Lower Boulonnais. But from near Longueville the road runs with tolerable distinctness northwards to Caffiers, and from thence eastwards to the coast at Wissant.

* *Archæologia*, vol. xlii. p. 30, 1869.

CHAPTER XXIV.—LIMESTONES, MANURES, CLAYS, &c.

Purbeck Limestones.—The succession of strata has been given in Chap. III.; some notes collected by MR. C. GOULD on the mode of working the stone may appropriately be given here. They were obtained from intelligent men who had actually worked in the pits, and are no doubt reliable.*

Limekiln Wood.—The bell pits, where of any depth, require five men to sink them. Two remaining at the windlass, while the others work below. A circular shaft, 4 feet in diameter, is sunk for 20 feet. The quarrymen then commence to bell it out, increasing the diameter with the depth, so that eventually the base of a pit, 50 or 55 feet deep, is as much as 20 feet across. No timbering is necessary, unless, as is sometimes the case, the quarrymen proceed to drive out horizontal galleries from the base of the pit.

The amount of water in these pits is rarely great, and pumps were seldom erected; but "pinnocks," or square timber troughs, 8 inches square, were laid down from one pit to another, and so continued to lower ground.

Estimate of the Cost of the Lime (furnished by a Quarryman at Limekiln Wood).

	£	s.
Payment of royalty to the landowner, per kiln - -	2	2
Payment to quarryman for extracting the stone and burning it - - - - - - - -	5	10
Cost of team to carry the stone to the kiln, &c. - -	1	10
Cost of wood for fuel; about 2,000 faggots, at 3*s.* 6*d.* to 4*s.* per hundred - - - - from 4 to 5		
The total cost averages about - - -	£14	0

The capacity of the kiln here being about 640 bushels.

If purchased at the kiln from the lime-burner, instead of the whole kiln having been contracted for:—

6*d.* per bushel is paid for "Grays." } Delivered into Hastings
7*d.* „ „ "Blues." } at 2*d.* per bushel more.

The Blue limestone makes by far the best lime for building purposes, but the Grays are by many considered equal to the Blues for agriculture.

Archer Wood.—The quantity of the Greys at Archer Wood was but small, and in consequence of their laying near the surface they were extracted by bell pits in the ordinary manner.

With respect to the Blue limestone, however, the miners proceeded in the following manner:—

The general dip of the strata having been ascertained to be towards a point a little west of south, they commenced by sinking

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* These workings have been for years abandoned, and for this reason the estimates of the *cost*, as here stated, can have but little value now.—W. T.

a main pumping shaft, upon the north side of the valley formed by the small stream which traverses the wood; and at a depth of about 60 feet two levels were driven out to the right and left respectively, at a slight angle to the strike of the beds. These, which were called the wet levels, constituted the southern boundary of the workings, and served to drain the whole of the excavations subsequently made. Two pumps were mounted in the main shaft, and were driven by the power derived from an overshot wheel.

These necessary preliminaries having been completed, the whole length of the levels was divided into distinct faces of work, by means of galleries driven out at right angles to them, and subsidiary shafts were sunk for the purpose of winding up the stone.

A face of work was then gradually carried forward, the miners supporting the roof as they advanced by means of forks or upright timbers with cross props, the limestone being brought to the foot of the shaft along the gallery, while the shale and refuse portion of the stone was thrown back into the "gobbin" behind.

When the distance of the face of work from the last level had reached the limits beyond which the stone could not be drawn with economy, in consequence of the increased expenditure attendant upon the underground carriage, a second face of work was treated in a similar manner, and the operation repeated until the whole had been advanced to equal distances from the main "wet-level."

Levels were then driven parallel to the first two, a second series of shafts sunk, and the extraction of the stone recommenced in the manner which I have just described. Eventually a third series was sunk.

The dip of the beds was found to increase considerably as the workings stretched northwards, and I feel but little doubt that they were limited by a fault which brings the beds up against the Ashdown Sand in that direction.

The amount of the interval between the shafts was of course determined by the expense of underground carriage. It appears, from my informant's account, to have been from 12 to 14 yards along the main wet-level, and about 20 yards along the galleries; the labour of carrying the stone being diminished in the latter case, by the downward slope of the strata. Occasionally, light waggons were employed underground, when the distances between the shafts were increased, intervening "fork headings" being driven.

The shafts varied in depth, according to their position, from 60 to 110 feet; their form was that of a parallellogram, of which the dimensions were 4 feet by 3, inside the timbering. The timber was obtained from the estate, and oak alone was used.

The horizontal timbering consisted of square frameworks about 4 inches by 3 inches, repeated every two feet; these served not only to protect the walls of the shaft, but were also used by the miners for the purpose of ascent and descent.

The "backing," or vertical framework, consisted of "slabs" or the outside portions of oak timbering, closely driven together.

A horse whim was erected at the top of each shaft, and "lacing boards" or planks laid along it, for the buckets to rub against.

Only the first, second, and third limestones were extracted at first, the fourth being left to form a roof when the fifth and sixth were extracted; the height of the galleries in the first case was 5 feet, in the second 4 feet.

I must add with respect to the galleries, that care was always taken to keep one side of them, while in use, protected by firm unbroken ground; the hard refuse, stone, &c. was packed in to form a wall upon the other.

Cost of the Lime.—The blue lime was sold for 9*d.* per bushel, for building purposes, but the price was reduced to 8*d.* per bushel, if intended to be laid upon the land.

It was delivered in Hastings for 1*s.* per bushel.

A kiln formerly contained 1,000 bushels; and two men could burn three kilns in a week, working two hours each alternately. Three additional men were required to fill and empty them. The capacity of the kiln was afterwards reduced to 600 bushels. The miners usually worked in bodies of three or four.

As in Limekiln Wood, the fuel used appears to have been principally faggots and furze. The latter was occasionally sown for the purpose, and was cut every three years.*

C. GOULD.

YOUNG, in his Agricultural Survey, gives a full account of the processes employed for mining and burning the stone. He says:—"the two sorts of limestone in use are very different in the effect which the fire has upon them. The one, a grey stone, ... will at first bear the necessary amount of heat without danger; is very tough, and will open a little without flying; but upon fire being continued too long will vitrify. The other is a blue stone, very much inclined to crack and fly to pieces, and requires great attention, to prevent the stone forming the arch from breaking, and letting in the kiln. By continuing the fire too long, and too fiercely, it runs into a powder, although it does not vitrify like the other: it is a much stronger cement than the grey, or chalk."†

The following extract from SIR W. C. PASLEY'S work on Limes, Cements, &c.,‡ will show the hydraulic qualities of the Purbeck lime. It is doubtful whether the blue or the grey lime was employed in the experiment, probably the former:—

"I think it probable that there are many excellent hydraulic limes in various parts of England, which from the expense of carriage cannot be brought into the London market; but the only lime of this kind that I am personally acquainted with, and of which I sent for some, after hearing it praised by an experienced builder of London, was from Rosehill, in Sussex. I never saw

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* Furze was the common fuel for lime-burning in other parts of the Weald, when wood was getting too dear, and coals were yet hard to get.—(W. T.)

† *General View of the Agriculture of the County of Sussex*, p. 208 of 8vo. ed.

‡ Page 89.

this lime in its natural state, as the only specimen I could obtain, which was forwarded to me in a bag, had been previously burned, and probably ground, for it was in fine powder, and so very stale, that it threw out scarcely any heat on being mixed with water. I therefore made it up into balls with water, which, when dry, I burned in crucibles, knowing that reburning restores stale or slaked lime to its original state of quicklime. On trying the Rosehill lime in this improved state, in the usual manner, by making it up into moist balls after pounding it when fresh from the fire, it appeared to approach very nearly to a water cement; for on allowing these balls, which now threw out great heat, about a quarter of an hour to cool, and then immersing them in a basin of water, they did not go to pieces for several weeks, so that this lime seemed rather superior in its hydraulic powers, even to the blue lias of Lyme Regis, the best lime with which I had an opportunity of comparing it."*

At the time the Purbeck limestones were worked they were the chief source of lime for Wealden farmers for many miles round. Large quantities of *Chalk* were, however, burnt at Hastings. It was brought by sea from the Holywell quarries near Beachy Head.

This trade has ceased for many years,† and the farmers of nearly the entire Weald are wholly dependent on railway communication for their supply of Chalk-lime. The lower beds of Chalk are burnt for this purpose; quarries are open all round the country at the foot of the Chalk escarpment, and in the transverse valleys which intersect it. The same quarries also supply lime for building.

The Kentish Rag is burnt for lime in some places. At Saltwood, in and before 1858, 15,000 bushels per annum were burnt.‡

The Paludina limestones are used occasionally, but rarely.

Marl.—All over the clay districts of the Hastings Beds, and very frequently over the Weald Clay, there are large holes, now mostly full of water, called "Marl pits."§ From these pits *shale* was formerly dug in large quantities to lay over the surrounding fields; it was applied indiscriminately to light and heavy soils. This shale was called "Marl," although it contains but little carbonate of lime. It is rarely dug at the present day, and then is only laid on light land, where it may be of service; but the general opinion now is that it is worthless, and many farmers say that their land has been spoilt by its use. "Marl" has been thus

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* From the following paragraph in YOUNG's *Agric. of Sussex*, p. 13, it would appear that this character of the limestones was well known. "The Sussex limestone, upon trial, has been discovered to be superior both to the Maidstone [Kentish Rag] and Plymouth stone, and it is now supposed that for cement, none equal to it is found in the kingdom." YOUNG is here speaking of the Purbeck limestones. The "Bastard Blues" are best suited for cement.

† Lime kilns were to be seen on the east side of Wellington-square, as late as 1816. *Handbook for Hastings*, p. 36 of ed. 1864. In 1797 the average annual quantity of lime produced was 120,000 bushels (*Hastings Guide*, 2nd ed., p. 66, 1797).

‡ *Mineral Statistics for* 1858, p. 179.

§ These pits must not be confounded with the small "mine pits," from which ironstone was formerly obtained.

employed in the Weald from early times. GERVASE MARKHAM, in 1625,* says that trees 200 and 300 years old were then growing in old Marl pits, but that its use had been discontinued till 30 or 40 years before the time in which he wrote. This writer describes the Weald as "of a very barren nature, and unapt either for pasturage or tillage, until that it be holpen by some manner of comfort, as dung, marel,† fresh earth, fodder, ashes, or such other refreshings" (p. 2). In the virtues of marl, as such a "refreshing," he had great belief, describing it as "a fat, oyly, and unctuous ground lying in the belly of the earth, which is of a warm and moist temperature, and so most fertil; seeing that heat and moisture be the father and mother of generation and growth; how be it this is not a pure and simple marrow (as that which lieth in our bones), but a juyce or fat liquor mingled with the earth; as is the fat which lieth mixed and dispersed in our flesh, so as the one may be drawn away, and the other remain" (p. 5).

Some of the *middle* Gault contains a good deal of lime;‡ that at Farnham has nearly 5½ p. c.; that at Folkestone has a considerable quantity—MR. PHILLIPS § says 30 p. c.; and DR. MANTELL ‖ found a similar proportion in the Gault at Ringmer.

The Gault has sometimes been dug for claying the neighbouring sands of the Folkestone Beds, particularly near Farnham. The middle Gault is best suited for this.

The richest mineral manure of the district is the marly green sand which lies at the top of the Upper Greensand. This contains a large per-centage of phosphate of lime, and has long been used in the neighbourhood of Farnham. Interspersed through the marl are numerous fossils and nodules, all phosphatic. A very careful series of analyses was made of these by PROF. WAY.¶ The following analyses are of the marl and fossils dug at Dippen Hall, Farnham. The fossils formed 61 p. c. of the whole.

—	Fossils.	Marl (Potash and Soda not estimated).	
		Coarse Particles.	Fine Mud.
Insol. siliceous matter	9·84	21·85	26·25
Soluble silica	2·36	20·18	18·11
Organic matter	3·26	6·25	5·95
Phosphoric acid	27·60	7·80	10·38
Carbonic acid	6·96	10·91	10·34
Lime	44·56	20·58	19·87
Magnesia	·81 (including loss.)	1·59	·87
Oxide of iron and alumina	4·61	8·18	6·18
	100·00	97·34	97·95

* *The Enrichment of the Weald of Kent*, 4to. Lond. The quotations are from the Edition of 1683. The book was first published in 1625.

† MARKHAM varies the spelling of this word; in the course of three pages it occurs as margle, marle, marl, marel, and male.

‡ See p. 151, and analyses on p. 391.

§ *Trans. Geol. Soc.*, vol. v. p. 37.

‖ *Fossils of the South Downs*, p. 81.

¶ *Journ. Roy. Agric. Soc.*, vol. ix. p. 71.

PROF. WAY remarks "that the greenest marl is not always the richest, but, on the contrary, that which is intermixed with calcareous matter of a white and brown colour affords the largest per-centage of phosphoric acid."

The marl which has been most constantly employed in agriculture is that of the lowest Chalk beds; it is sometimes called "malm." It is worthy of note that the marl from this bed has preserved its celebrity, notwithstanding all the changes of opinion which agriculturists have passed through regarding other marls. MR. BUCKMAN* gives a table of the various marls which have from time to time been used, from which it appears that 50 or 60 years ago marl was extensively dug from the New Red, Lias, and Chalk Marl; less commonly from the Silurian beds, Oxford, Kimeridge, and London Clays. The use of all these, excepting Chalk Marl, has greatly diminished, and some (Silurian, Oxford, and Kimeridge) are entirely discontinued.

That of the New Red Sandstone is again coming into use, and will do so still more as the waste lands of that formation are gradually brought into cultivation.†

Phosphate of Lime.—This occurs on several horizons, but only in sufficient quantity to be of economic value in the Upper Greensand, and at the base of the Gault. It occurs as "Molluskite" in the Hythe Beds, scattered in irregular masses, generally of small size, through the stone; this is particularly abundant near Maidstone. Phosphatic nodules with fossils also occur in the Hythe Beds near Godalming, and in the Atherfield Clay at Stopham, near Pulborough.

At Great Chart, near Ashford, and again at Grove Bridge, the bottom of the Sandgate Beds contains many phosphatic nodules. At the former place stone is quarried from the Kentish Rag, and the overlying beds are thrown on one side as waste. The nodules here might be worth separating for local use.

The best known and the most constant horizon at which phosphates occur, is at the junction of the Gault and Lower Greensand. They have been worked to some extent in the neighbourhood of Farnham. The amount of Phosphoric acid varies very much. Some specimens from Folkestone were found by PROF. WAY to contain 25 p. c., equal to 52 p. c. of Phosphate of Lime; another analysis gave only 4·8 p. c., the Phosphoric acid, in this case, existing in combination with iron. Phosphatic fossils from Wracklesham gave nearly 21 p. c. An old analyses by BERTHIER‡ of the nodules from Wissant gave 24 p. c. of Phosphoric acid.

This bed of nodules at the bottom of the Gault is exceedingly constant around the Weald, excepting for some 10 or 12 miles,

* "Geology of Wiltshire," *Journ. Bath and W. of Eng. Agric. Soc., N.S.*, vol. xiii. p. 84, 1865.

† See a paper by MR. R. B. GRANTHAM, "On the works for reclaiming and marling the Forest of Delamere," *Journ. Roy. Agric. Soc.*, vol. xxv. p. 369, 1864. Several analyses of the marls are there given.

‡ *Annales des Mines*, tom. v. p. 203, 1820.

possibly more, in Sussex (see p. 150). It appears to be quite constant round the Boulonnais, excepting, perhaps, where the Gault lies immediately over Palæozoic Rocks.

There are other horizons in the Gault at which phosphatic nodules occur,* but they are of inconsiderable thickness, and are probably inconstant.

More recently some phosphate works have been established at Cheriton, near Folkestone. The nodules occur in two beds; the lower one, 12 to 15 inches thick, is the junction bed of the Gault and Lower Greensand. Here it is generally dark in colour and always sandy. Separated from this by two feet of clay is another and more variable bed, three to six inches thick. In the clay between these beds, and also in that above them, scattered nodules occasionally occur.

The nodules are extracted by means of trenches, 6 feet wide; all the material is taken out, and the scattered nodules picked out by hand. The two phosphate seams are dug out and washed; sometimes the lower and sandy seam is sifted before being washed. The washing is effected in a circular frame, through which a constant stream of water is running; the nodules being kept in constant motion by travelling rakes. When washed, the nodules are sifted; the coarser material consists almost entirely of phosphate, the few masses of iron pyrites are easily distinguished and taken out. The finer material contains a large quantity of pyrites, or of phosphate having so much pyrites as to be worthless. All this is carefully picked over by boys. The finest material passes with the sand and clay through the washing apparatus, and is caught by a sieve; this is chiefly pyrites.

The phosphates from the Upper Greensand have been largely worked near Farnham. The nodules occur most abundantly towards the bottom of the green sandy "marl" already mentioned, but the fossils scattered through it are also generally phosphatic. An analysis is given on p. 388. Average samples of "Coprolites" from Cambridgeshire (Upper Greensand), and from Suffolk (Crag), give about 26 p. c. of Phosphoric acid. †

Phosphatic nodules from the Upper Greensand are dug in the Bas Boulonnais; but they are generally simply crushed and laid on the land, without undergoing any chemical treatment.

Soluble Silica.—This is one of the most remarkable products of the Upper Greensand; it has been fully described by Messrs. WAY and PAINE.‡ It occurs in greatest abundance in those beds of malm rock which are of least specific gravity, and of a light brown or fawn colour. The highest p. c. of soluble silica observed is

* See the section given on p. 146.

† See a paper by DR. VOELCKER, *Journ. Roy. Agric. Soc.*, vol. xxi. p. 350, in which analyses of various phosphatic materials are given. An excellent account of this subject is also given by M. DAUBRÉE in *Annales des Mines*, Ser. 6, tom. xiii. p. 67, 1868.

‡ "On the Silica strata of the Lower Chalk," *Journ. Roy. Agric. Soc.*, vol. xiv. p. 225. To this paper, and to those in vols. ix. and xii. of the same journal by the same authors, the reader is referred for an exhaustive account of the chemical and agricultural character of the Upper Cretaceous Rocks, particularly Surrey.

70 p. c., the richer portions varying from this high amount down to 20 p. c. This rock has been very largely dug at Farnham for manure, and is particularly well suited for light sandy soils. Wheat grown on this silica rock is said to have long been celebrated for the stiffness of its straw.

This silica rock of the Upper Greensand is as remarkable for its wide distribution, as are the phosphates already described. It is found in several places round the Weald; a specimen from Merstham giving 40 p. c. of soluble silica. The rocks of the Isle of Wight give much smaller quantities. The Upper Greensand of the Ardennes contains 56 p. c.* That of the Pays de Bray 50 p. c.†

ANALYSES of UPPER CRETACEOUS ROCKS from the borders of SURREY and HANTS. (Dried in the air at 212° Fahr.), by Prof. J. T. WAY.‡

—	Gault.			Upper Greensand.			Chalk.	
	Lower Gault.	Middle Gault.	Upper Gault.	Soft Rock above the Gault.	Firestone Rock.	Fossiliferous Green Marl.	Grey Marl.	Marl.
Combined water with a little organic matter.	7·68	6·38	5·47	4·15	1·60	4·21		
Soluble in dilute acids :—								
Silicic acid -	16·65	26·89	24·80	46·28	Not ascertained	31·88	2·16	2·11
Carbonic acid -	—	3·13	—	—	35·47	Small quan. not determined.	29·96	36·73
Sulphuric acid -	trace	0·30	trace	trace	trace	0·45	0·21	0·06
Phosphoric acid	trace	trace	trace	trace	0·15	3·76	0·21	0·05
Chlorine -	0·03	trace	0·03	—	0·04	trace	0·08	0·04
Lime - -	0·66	5·34	0·75	0·26	44·90	5·61	41·52	49·16
Magnesia -	0·77	0·35	0·26	0·07	0·28	0·85	0·30	1·18
Potash - -	0·66	0·74	0·35	0·79	0·18	3·21	0·26	0·11
Soda - -	0·15	0·31	0·16	0·43	0·30	1·20	1·64	1·36
Protoxide and peroxide of iron.	3·16	7·25	4·56	6·12	0·60	16·91	2·20	1·74
Alumina -	1·24	6·50	0·94	3·15	1·46	0·74	0·11	0·20
Insoluble in dilute acids :—								
Lime - -	trace	1·61	1·29	2·91	0·41	1·52	1·71	0·22
Magnesia -	trace	0·91	0·82	trace	0·10	1·09	trace	trace
Potash -	1·53	2·16	1·57	1·51	0·07	0·45	0·32	0·15
Soda - -	1·90	0·42	0·64	0·60	0·43	0·31	0·07	0·05
Alumina with a little oxide of iron.	19·06	7·88	11·29	14·20	0·92	5·75	2·57	1·42
Silicic acid and sand.	46·51	29·83	47·07	19·53	13·09	22·06	16·68	5·42
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

* Quoted by WAY and PAINE from KNAPP's "Technology."
† LAPPARENT, *Bull. Soc. Geol. de France*, Ser. 2, tom. xxiv. p. 230.
‡ *Journ. Roy. Agric. Soc.*, vol. xii., p. 544.

—	Chalk without Flints.	Chalk with Flints.	
		Lower.	Upper.
Sand and siliceous matter, insoluble in acids -	2·04*	0·66	0·87
Silicic acid, soluble in acids - - -	trace	—	—
Carbonic acid - - - - -	42·14	42·98	42·57
Sulphuric acid - - - -	0·31	trace	0·09
Phosphoric acid - - - -	0·07	0·08	0·08
Chlorine - - - - -	—	—	0·08
Lime - - - - - -	54·37	55·24	55·18
Magnesia - - - - -	0·25	0·10	0·30
Potash - - - - -	0·08	0·06	0·22
Soda - - - - - -	0·19	0·14	0·21
Oxide of iron - - - - -	0·55	0·74	0·40
Alumina - - - - -	trace		
	100·00	100·00	100·00

Bricks and Tiles.—These are largely made all over the clay districts of the Weald, and along the outcrop of the Gault. The largest brick works are on the banks of the Medway; the bricks are made from the Gault at Burham and Aylesford, and from the old alluvia of the Medway near Maidstone.

In the smaller brickyards the Gault is generally mixed with sand for bricks, but is used alone for tiles.

A great deal of information as to the estimated annual make, &c. is contained in the Mineral Statistics for 1858, Part ii.

The following table gives the results of Mr. G. Maw's experiments upon clays from our district:—†

Description.	Shrinkage		Per Cent. of Coarse Matter.	Remarks.
	Refined Clay.	Coarse Clay.		
	per cent.	per cent.		
Gault (railway cutting near Fittleworth, Sussex).	8·0	8·0	2·04	This specimen was from near the bottom of the Gault.
Fuller's Earth (between Red Hill and Nutfield).	11·0	13·0	13·95	
Weald Clay (railway cutting 3 miles south of Red Hill).	9·0	4·0	3·30	
Weald Clay, resting on Horsham stone (Horsham).	9·0	4·0	2·375	
[Fairlight Clays ?] White pipe-clay (Foot of East Cliff, Hastings).	10·0	8·0	1·19	Contains basic sulphate of iron 1·68 p.c.; bisulphide of iron 0·094 p.c.

* This includes clay insoluble in acids.

† Appendix to Catalogue of Pottery, &c., in Museum of Practical Geology, 2nd ed., 1871, p. 229.

Fuller's Earth.—This has been dug near Nutfield for a very long time. It was formerly of greater value than now for "fulling" or cleaning cloth, other processes having been introduced.

"The exportation of fuller's earth, or fuller's clay, supposed to be necessary for preparing and cleansing the woollen manufactures, has been subjected to nearly the same penalties as the exportation of wool. Even tobacco-pipe clay, though acknowledged to be different from fuller's clay, yet on account of their resemblance, and because fuller's clay might sometimes be exported as tobacco-pipe clay, has been laid under the same prohibitions and penalties."* There was a curious trial in 1693, turning upon whether a certain potter's-clay were fuller's earth or not. In the evidence some of the qualities of fuller's earth as distinguished from potter's clay are set forth.† " . . whereas this makes the best Clay Wall in *England*, if it were of the nature of Fuller's-earth, upon the first wet Weather it would all fall to the Ground." "The said *Warner's* Clay, tho' never so often dissolved in Water, may be brought into a Body again, and will work like Wax into any shape, whereas Fullers Earth being once dissolved is never to be got into any Body, but when it is dry crumbles like Sand, and all the art of Man can never make a Pot of it."

MAJ.-GEN. PASLEY, in the course of his experiments upon water-cements, tried a mixture of Chalk with Fuller's earth (from Reigate) but this entirely failed, although "any fine *clay* will make an excellent water cement in combination with chalk," if proper precautions be used. Fuller's earth "when made up into a form with water is not plastic, but splits in drying in the air, and when burned in the fire with every precaution, instead of forming a sound brick, breaks into a number of small fragments in the state of porous unsound slag or scoriæ. But on washing the fuller's earth repeatedly, in order to get rid of the small portion of salt, also said to form a part of that substance, we found that it became more plastic, and in this state it frequently succeeded in forming a water-cement, but inferior to that of the plastic clays."‡

The composition of fuller's earth from Reigate, according to KLAPROTH, is as follows:—§

Silica	53·00
Alumina	10·00
Peroxide of iron	9·75
Magnesia	1·25
Lime	0·50
Potash	Trace
Chloride of sodium	0·10
Water	24·00
	98·60

* SMITH'S *Wealth of Nations*, book iv. chap. viii. This prohibition was withdrawn in 1721.

† Printed in Catalogue of Pottery, &c. in the Museum of Practical Geology, Appendix B. p. 250, 2nd ed., 1871.

‡ *Observations on Limes, &c.*, 2nd ed., p. 57, 1847.

§ BRISTOW'S *Glossary of Mineralogy*, p. 145, 1861.

It is not stated of the foregoing analysis which kind of fuller's earth was used.

Other analyses of both kinds give the following:*—

——	Blue.	Yellow.
Silica - - -	42·0	44·0
Alumina - -	18·0	11·0
Oxide of iron - -	6·0	10·0
Magnesia - -	2·0	2·0
Lime - - -	4·0	5·0
Soda - - -	5·0	5·0
Water - - -	23·0	21·0
	100·0	98·0

Both blue and yellow varieties fetch about the same price. "The quantity of earth transported from the pits annually is about 6,000 tons, of which about 4,000 tons are of the yellow variety. The manufacturers of fine cloth make use of the blue only. . . . The yellow earth has a much wider distribution, being employed in the manufacture of every fabric of coarse woollen goods."† In 1858 the quantity sent away annually amounted to about 12,000 tons.

Sulphate of Barytes is now less frequently found in the Fuller's-earth than formerly; it has occurred in very large masses. Every fragment of this or of other hard matter is carefully removed from the earth.

The neighbourhood of Nutfield and Reigate is the only place in the south-east of England from which fuller's earth is now got in any quantity. It used to be dug at Deptling and Vintners, near Maidstone, and near Petworth in Sussex. That near Maidstone seems to have been worked in 1729 (see p. 130); but STEVENSON, in his "Agriculture of Surrey,"‡ speaks of "the recent discovery of a pit of the yellow or better sort near Maidstone," so that the old workings there must have been forgotten.

DR. FITTON mentions "Fuller's-earth" (in 2 two-feet beds) as occurring at Hastings, in the "heights between Warrior's Gate and the White Rock."§ This is probably in what is coloured as Tunbridge Wells Sand on the Geological Survey Map.

Miscellaneous.—Some shales of the Purbeck Beds, near Poundsford, are bituminous, and from them various products have been obtained, as mentioned on p. 38.

* *Mineral Statistics for* 1858, part ii., p. 377. The authorities are not stated.

† Letter from W. CONSTABLE (in 1839) to DR. MANTELL. See BRAYLEY'S *Hist. of Surrey*, vol. i. p. 146, 1841.

‡ P. 52 of 8vo. ed., 1813.

§ *Trans. Geol. Soc.*, Ser. 2, vol. iv., p. 164.

Tripoli powder has been manufactured from the "poor argillaceous iron-ore" of the Wadhurst Clay, near Ashburnham.*

Glass-sand is often dug from the Folkestone Beds; large quantities are got for this purpose at Reigate, and also in Kent at Aylesford, Berstead, Hollingbourn, and elsewhere.

The rock-sands of the Hastings Beds are often well adapted for this purpose. These are often almost white, and are somewhat coarser in grain than the ordinary Wealden sandstones.

The Folkestone Beds are everywhere dug for building-sand.

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* FITTON, *Geol. of Hastings*, p. 50.

CHAPTER XXV.—GEOLOGICAL DISTRIBUTION OF POPULATION AND DISEASE.

In a district in which the surface soil is generally greatly influenced by the underlying rock, it might be expected that there would be some correspondence between the range of the strata and the arrangement of the population. This is very markedly the case in the Weald.

The most obvious example of this agreement is the continuous line of villages lying under the steep slope of the South Downs; generally on the Upper Greensand terrace, but sometimes at the base of the Chalk. This is the case all through Sussex and Hants. Through the greater part of Surrey the dip of the beds is high, and their outcrop narrow, but the same tendency is evident, and in Kent it is again plainly seen. There are 176 towns and villages in Sussex in the Weald (within the Chalk escarpment), and of these 35, or 20 per cent., are along the narrow band of Upper Greensand; whilst on the adjoining Gault clay there are only two—Heyshot and Wiggonholt.* Hants has 13 of its Wealden villages on Upper Greensand, and six on Lower Greensand; *none* on Gault. Surrey has none on Gault, but six at the foot of the Chalk escarpment. In Kent there are 19 at the foot of the Chalk and only two on Gault: of these, one (Brooke near Ashford) consists of a church and half-a-dozen houses; whilst Trottescliffe is quite at the outcrop of the Gault touching the Chalk. The total number of towns and villages in the Weald is 397, of which 73 (or 18 per cent.) are either at the foot of the Chalk, or on the Upper Greensand terrace.

In Kent a considerable number of villages (13) occurs on the face of the Lower Greensand escarpment, at or near the junction with the Weald Clay. Here springs generally occur; to this cause, together with the fertility of the soil, the choice of the site is no doubt owing. Similar causes have determined the position of the Upper Greensand villages. The Gault is a wet and stiff soil, difficult to cultivate; and in early times, when not wooded, was probably always left in pasture; even now it is chiefly so—hence the absence of villages.

There are in all 98 towns and villages on the Lower Greensand plateau, and these prefer the lighter soils. On the Hastings Beds in Kent and Sussex there are 97 towns and villages, 79 of which have sandy sites. In the alluvial tract of Romney Marsh there are 18; the two most important of which, Lydd and New Romney, are on shingle.

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* Coates and Hardham are on gravel overlying Gault, with consequently a light and generally dry soil. For our present purpose they, like Snodland (in Kent), may be considered as having nothing to do with Gault. Wiggonholt is just at the border of the gravel. Perhaps Heyshot is the only village in Sussex which is truly built on Gault alone.

The more important towns have a decided preference for Lower Greensand, as a glance at the map will show. There are very few of any size on Weald Clay, the largest being Hailsham; this indeed is partly on sand, a subordinate stratum of the Weald Clay. Billinghurst, though a market town, is small. Edenbridge and Tunbridge, the latter a good sized town, are on gravel.

There are no large towns on the Hastings Beds, excepting Tunbridge Wells, and Hastings with St. Leonard's. All the larger villages and market towns are near the border of the central country (*i.e.*, near the Weald Clay), excepting Battle, which owes its position to its abbey.

If from the actual position of the towns we turn to the parish boundaries, further evidence of agreement between the arrangement of the strata and the grouping of the population will appear.

We have already mentioned that a line of villages occurs under the Chalk escarpment, either at its foot or on the Upper Greensand terrace. The parishes belonging to these villages *run up the Chalk escarpment,* and generally more or less over the plateau above; but very few of the villages upon the Chalk plateau have their parishes running *down* the escarpment. This is a very remarkable fact, and it is true of the entire Wealden area. In the other direction, or towards the centre of the country, the parish whose village is at the foot of the Chalk escarpment, extends over the Gault to the Lower Greensand. If the area of this be tolerably wide the parish will stop there; but if it be narrow the parish will extend beyond the Lower Greensand to the Weald Clay.

Where the Lower Greensand area is wide, and the parish from the Chalk escarpment stops upon it, there is another parish going *down* the Lower Greensand escarpment, but the village belonging to this generally lies *upon* the Lower Greensand; this is exactly the reverse of the parishes along the Chalk escarpment.

There are throughout the whole of the Chalk escarpment around the Weald 125 parishes, of these 119 conform to the rule here given (the village lying below the hill), whilst only six in the whole area act in the other way.

This relation of villages and parish boundaries to the Chalk escarpment prevails very generally over the Chalk districts of England; and it is doubtless due to the same general cause, which we will now endeavour to ascertain.

The ancient condition of by far the larger part of England was that of thick forest. There are, however, some extensive tracts which seem to be unsuited for the growth of dense native wood; such as bare Chalk Downs, Limestone Wolds, and rocky moors. It is over such tracts that we find the larger proportion of our pre-historic remains. The bare Chalk Downs of Sussex are thickly covered with Celtic forts, tumuli, &c., whilst in the interior of the Weald traces of the Celtic occupation are com-

paratively rare. The hill-fort served as a refuge for the inhabitants when threatened with invasion; the common habitations of the people were probably for the most part situated on lower ground, in the long Chalk valleys, which are now mostly dry, but were then perhaps well watered.

While we are thus certain of the ancient condition of much of the Chalk area, we are equally certain of the condition of the Weald Clay and Hastings Beds district. All this area was one vast wood and waste, the ancient *Sylva anderida* or Andredswald. The wood would be very dense over the clays; less so over the sands. Of the condition of the Lower Greensand we are less certain. Probably it was in great part wooded, but if so it was certainly largely cleared in very early times; and the wood would be less thick than over the Weald Clay.

We know that the Weald proper, or that part of the country below the Lower Greensand escarpment, was the part latest cultivated. Even as late as ELIZABETH's time swine are said to have run wild here; and LAMBARDE, writing in 1576,* tells us that some believe "it was a great while togither in manner nothing els but a desert, and waste wildernesse, not planted with Townes, or peopled with men, as the outsides of the shyre were, but stored and stuffed with heards of Deere, and droves of Hogs only." Pannage for hogs in the Weald is, in old documents, mentioned much in the same way as we now speak of pasturage for sheep on uninclosed mountain moorlands.

Domesday Book mentions but very few places wholly within the Weald. The manors round the border extend into the Weald; of these a large number are named.

The date at which parishes were first formed is generally involved in great obscurity; but we know that, in the Weald of Sussex, their bounds were not finally settled till the century after the Conquest; when the see of Chichester was removed thence from Selsea.†

In the original settlement of the country the parts first occupied would probably be those nearest the outside. Those spots which yield the most fertile soil would naturally be selected, and regard would also be had to convenience of water-supply. These conditions are found at the base of the Chalk escarpment; and here, probably, the earliest settlements were placed.

These earliest settlements, lying close together, necessarily extended their boundaries up the Chalk on the one side, and towards the Lower Greensand on the other. The land immediately around the dwellings would be taken under the plough, the steep face of the escarpment would have been then, as now, in grass; for the slope is generally too steep to allow of ordinary arable culture, and traces of terrace cultivation, though occurring sometimes, are not at all common. We have no means of knowing the primitive condition of the Gault area; but, judging from

* Perambulations of Kent, p. 191 of ed. 1826.
† DALLAWAY's Hist. of Sussex, vol. i. p. li.

its soil and the trees that thrive best upon it, it is likely that oak-timber covered the greater part. What was the condition of the Lower Greensand is matter of conjecture only; but if it had been forest land at all like that of the Wéald Clay, we should expect to find the fact well attested by local names. There are some "charts"* in Kent, and a few "hursts" and "fields" in Sussex; but "dens" and "folds," as we shall presently find, are exceedingly rare.

The most fertile tract in the district being thus occupied, the later settlements necessarily took place further in the country, on the Lower Greensand plateau. In the division of the land consequent on these later settlements the boundaries were already defined in the direction of the Chalk escarpment; but towards and over the Weald Clay, the land was almost wholly unoccupied. Hence clearings gradually took place over this part. It is of this later division that we find such striking evidence in local names, especially in Kent. MR. KEMBLE, in his Chapter and Appendix on "the Mark," says:—"In looking over a good county map we are surprised by seeing the systematic succession of places, ending in -den, -holt, -wood, -hurst, -fold, and other words which invariably denote forests, and outlying pastures in the woods. *These are all in the Mark*, and within them we may trace, with equal certainty, the -háms, -túns, -worðigs, and -stedes which imply settled habitations. . . . . I will lay this down as a rule, that the ancient Mark is to be recognised by following the name of places ending in -den (neut.), which always denotes *cubile ferarum*, or pasture, usually for swine."† MR. KEMBLE applies this rule to Kent, and enumerates only twenty-five *dens*, three of which are in Sussex. But if the Ordnance map of Kent be looked through, these numbers may be very greatly increased. This subject has been partly worked out by the REV. ISAAC TAYLOR, who has tabulated the names in the Weald according to their geographical position.‡ The results at which he arrives are sufficiently striking, but if we tabulate the words both according to their geographical and *geological* positions the results are extremely interesting. The accompanying table will make this clear.§

* The wooded tracts near Westerham and Sevenoaks are sometimes called Charts, as Brastead Chart, Seal Chart.

† The Saxons in England, vol. i. p. 480. The word "mark" bears a threefold meaning; 1st, "The land held by many men in common, or by several households, under settled conditions.....This is the first general division, the next in order to the private estates or alods of the Markmen." 2dly. Those who dwell within the Mark. 3dly. The *boundary* or *March*;—"Those forests or wastes by which the arable is enclosed and which separate the possessions of one tribe from those of another."—(p. 42.) There is a farm called *Shiremark F.*, just on the border of Sussex, on the high road from Dorking to Horsham.

‡ Words and Places, 2d. ed. p. 361, 1865.

§ This table and many of the foregoing remarks are taken from a paper read by me before the British Association at Brighton, and afterwards published in an extended form, with maps and sections:—"On the Relation of the Parish Boundaries in the South-east of England to great Physical Features, particularly to the Chalk Escarpment." *Journ. Anthrop. Inst.*, vol. iii. p. 32, 1873. (For some criticisms on this paper *see* MR. R. FURLEY'S History of the Weald of Kent, vol. ii., part 2 pp. 736–742, 1874.)

SUMMARY OF THE NAMES OF PLACES *in the Weald* (within the Chalk escarpment), ENDING IN

—	*-hurst.*						*-den.*						*-field.*						*-fold.*						
	Base of Chalk Escarpment and Upper Greensand.	Gault.	Lower Greensand.	Weald Clay.	Hastings Beds.	TOTAL FOR COUNTY.	Base of Chalk Escarpment and Upper Greensand.	Gault.	Lower Greensand.	Weald Clay.	Hastings Beds.	TOTAL FOR COUNTY.	Base of Chalk Escarpment and Upper Greensand.	Gault.	Lower Greensand.	Weald Clay.	Hastings Beds.	TOTAL FOR COUNTY.	Base of Chalk Escarpment and Upper Greensand.	Gault.	Lower Greensand.	Weald Clay.	Hastings Beds.	TOTAL FOR COUNTY.	TOTAL OF NAMES (*hurst, den, field, fold*) in Wealden part of County.
KENT (S. and S.W. part).	–	–	3	25	20	48	–	2	8	52	42	104	–	–	5	1	4	10	–	–	–	–	2	2	164
SURREY (S. part) -	–	–	3	31	–	34	–	–	1	–	–	1	–	–	2	14	2	18	–	–	–	9	–	9	62
SUSSEX (N. and N.E. part).	2	–	7	45	58	112	–	–	2	2	34	38	–	–	2	24	30	56	–	–	–	23	3	26	232
HANTS (E. part) -	1	–	–	–	–	1	–	–	–	–	–	–	2	–	1	2	–	5	–	–	–	–	–	–	6
Total for Geological Formations.	3	–	13	101	78	195	–	2	11	54	76	143	2	–	10	41	36	89	–	–	–	32	5	37	–
Total for whole Wealden area.	–	–	–	–	–	195	–	–	–	–	–	143	–	–	–	–	–	89	–	–	–	–	–	37	464

The boundaries of the ancient "Weald" are by no means well settled. The Saxon Chronicle tells us that the Andredswald was 120 miles long, and 30 miles broad. A line drawn from the Lower Greensand escarpment at Hunton through Hailsham to the Chalk escarpment of East Sussex is very nearly 30 miles in length; this is the *greatest* breadth of country which we can with certainty refer to the Andredswald. The length is more difficult to understand. From Folkestone to the extreme western angle of the Chalk escarpment, near East Meon, is only 96 miles. It is extremely unlikely that the forest extended beyond Folkestone, indeed it probably ended at the Lower Greensand near Aldington, 10 miles to the west of that place. It seems, however, to have been prolonged over the Hampshire Chalk. There is a village called Weald, five miles from the escarpment. Two miles from the escarpment and also on the Chalk is Privet; this is believed to be the place at which SIGEBERT was slain (755) in "the wilds of Andred."*

Whilst the boundaries of the ancient Andredswald are thus doubtful, we find a similar uncertainty in more recent times as to the extent of the "Weald." In Kent most writers take the Lower Greensand escarpment on the boundary. LAMBARDE, whilst taking this line for Kent, remarks of the Weald in general, that "a man may more reasonably maintain that there is no Weald at all, than certainly pronounce where it beginneth or maketh at end."† HASTED also tells us that the true limits are doubtful, but he says that where parishes are partly on the higher ground and partly on the lower (being divided by the Lower Greensand escarpment), they are sometimes distinguished as "Upland" and "Weald," as Sevenoaks Upland and Sevenoaks Weald, a distinction which is still maintained for this parish.‡

With regard to Surrey, especially its western part, the physical features are so strongly marked that one would expect to find the boundary equally unmistakeable. No one in these days understands by the "Weald of Surrey" any part of the Lower Greensand, but it seems that this or at least a part of it was included. YOUNG says:—§ "The Weald is an indefinite expression for a country, the limits of which are unknown. In a legal acceptation, it means the woodland districts in the counties of Sussex, Kent, and Surrey, in which woodlands pay no tithe."‖ HASTED has the following note:—"It is said that within the Weald

* FURLEY, History of the Weald of Kent, vol. i., p. 68, 1871. If the great forest extended thus far to the west would it not probably have extended still farther to join that of Bere and the "New" Forest? There is some reason to think it joined the Blean woods, near Canterbury. The connexion in such case would probably be by the "Clay-with-flints" over the Chalk; and also by the Lower Greensand.

† Quoted by MR. FURLEY, p. 56.

‡ Hist. of Kent, vol. i. p. cxxxiv., 1778.

§ Agriculture of Sussex, p. 4.

‖ "This was in some measure made up to the clergy by tithe-pannage, called *tack*, which was the tenth hog, or a compensation in lieu thereof."—FURLEY, p. 402. This was by no means a bad "make-up," for in early times wood was of very little worth, and oaks were valued, not by the quantity of wood they contained, but, by the number of swine that could feed under them.

the proof of woodland having ever paid tythe lies on the parson, to entitle him to take tythe of it, contrary to the usual custom in other places, where the proof of the exemption lies on the owner." There was a lawsuit in 1692 concerning the tithes of a place called Chert (or Charte) near Frensham, on the Lower Greensand of Surrey. It was decided that the woodland here was exempt from the tithe, it being in the Weald of Surrey.* If the Andredswald really extended to the Hampshire Chalk it must have included the Lower Greensand of Hampshire (Woolmer Forest, &c.) and might then very well have extended over the adjoining tract of Surrey. On the other hand there is some evidence of this district having been mostly open land. MR. KEMBLE gives a great number of local names from West Surrey, which are derived from those of the Saxon gods, and he remarks that this district "seems to have been a very pantheon of paganism."†

Turning now to Sussex, we find that, even among modern authors, the assumed boundaries of the Weald are doubtful. The agricultural writers generally take the Chalk escarpment as the boundary. MR. MARTIN, who resided at Pulborough, says‡:— "Provincially the clay country only is called 'the Weald' and the inhabitants of the Shanklin Sands [Lower Greensand] fertile or infertile, woody or bare, scarcely confess themselves denizens of the weald, although they are below the chalk. Strictly speaking perhaps they are right, although geologically and geographically, it is convenient to consider all the valley, weald, from chalk to chalk. The boundary of the *Sylva Anderida*, was the escarpment of the lower greensand, and there is good reason to believe that the Romans found all the tract of country between it and the chalk-hills, as they left it, well peopled and cultivated; whilst the clay country remained the impracticable forest to which the Saxons came to give another and more lasting name." I am not acquainted with the "good reason" for this supposed early occupation of the Lower Greensand country. Compared with the Chalk and Tertiary districts of Sussex the Lower Greensand is remarkably bare of Roman works; and when such occur they are generally either near the lines of Roman roads or in the larger river valleys.

Possibly the Lower Greensand escarpment not being continuous throughout Sussex has led to this uncertainty in the boundary of the Weald. In eastern Sussex, from the coast to about the London and Brighton Railway, there is no escarpment; the beds are thin and contain no hard rock. Here too, the parishes, as already stated, extend from the Chalk across more or less of the Weald Clay. Probably the Weald here would extend right up to the Chalk escarpment. But in the western part of the county

* FURLEY, History of the Weald of Kent, vol. i., p. 387.

In vol. ii. (Part 2, p. 640) MR. FURLEY gives an account of a lawsuit relating to some woodlands near Aylesford, which were decided to be outside the Weald.

† The Saxons in England, vol. i. p. 343, &c. MR. KEMBLE's reference to the "Hammer-ponds," near Thursley is unfortunate. They mark the site of old iron-works, and have only a remote relation to Thorr or his hammer.

‡ Geological Memoir on Western Sussex, p. 9.

the Lower Greensand escarpment is well developed and may there have been the boundary of the Weald.

The following is MR. C. H. PEARSON's description of the forest* :—

"The largest English forest in early times was the Andred's—Weald of Sussex, Hampshire, and Kent,—which constituted three kingdoms in itself, dividing Cantii, Regni, and Belge from one another in Cæsar's time, as it afterwards separated the South Saxons from the men of Kent on the east, and the West Saxons on the west. In Alfred's time it is said to have been a hundred and twenty miles long or longer, and thirty miles broad. Skirting the chalk hills of Surrey, it went as far north as Sevenoaks in Kent, and passed by Mereworth and Chart woods to Hurst, near Lymne; then fringing the Romney Marsh, it entered Sussex from Sandhurst; and Penhurst (wood-end), near Battle, was one of its southern boundaries. The chalk downs of Sussex separate it from the sea. Lysswood, Fairfield, and Clanfield, in Hampshire, probably represent its western boundary, though we also know of woods near Kelmiston and Exton."

This explanation is not very satisfactory. It places the wide Lower Greensand area of Surrey and Sussex within the Weald as forest land, and shuts out much of that of Kent. Penhurst is near Ashburnham, 6½ miles from the sea, and must certainly have been well in the forest. The name is more probably from the Celtic *pen*, a hill; the church and the few houses constituting the village are on a hill sloping to the east, south, and west; a little to the north there is a small outlier of Tunbridge Wells Sand.

In MR. FURLEY's History of the Weald there is a map showing "The forest of Anderida during the Roman occupation of Britain." The boundary is drawn exactly along the Lower Greensand escarpment; the forest is even shown running into the Lower Greensand country where the Greenhurst anticlinal brings up the Weald Clay.

If we are to take any definite boundary for this great forest tract, that assumed by MR. FURLEY is the most likely; but it cannot be rigidly enforced all through the district. Local names are a great help in this matter; and, as we have seen, they tend to fix the Lower Greensand as the boundary, the evidence being especially remarkable in Kent.

Geological Distribution of Disease.—This is a subject to which much attention is now being paid; and it is probable that, when thoroughly investigated, with sufficient geological and statistical data, it will yield very important results. Several authors have of late years written upon the subject, but the only investigation which fully and completely goes unto the question, so far as our district is concerned, is that which was conducted by DR. G.

* Historical Maps of England, p. 5, 1869.

BUCHANAN, of the Medical Department of the Privy Council.* This refers to the distribution of consumption in the south-east of England, and embraces the whole of the Wealden district. The information, both published and unpublished, collected by the Geological Survey was placed at DR. BUCHANAN'S disposal, and such aid as we could render was gladly given by MR. BRISTOW, MR. WHITAKER and myself.

The country is divided, for purposes of registration, into "registration districts," which are either coincident with, or are founded upon, the Poor Law Union divisions. Unfortunately these have no relation whatever to the great geological and physical features; if they had, the results would be far more interesting and important.

The general results arrived at by DR. BUCHANAN are stated by him as follows:—

"(1.) Within the counties of Surrey, Kent, and Sussex there is, broadly speaking, less phthisis among populations living on pervious soils than among populations living on impervious soils.

"(2.) Within the same counties, there is less phthisis among populations living on high-lying pervious soils than among populations living on low-lying pervious soils.

"(3.) Within the same counties, there is less phthisis among populations living on sloping impervious soils than among populations living on flat impervious soils.

"(4.) The connection between soil and phthisis has been established in this inquiry—

"(*a.*) by the existence of general agreement in phthisis mortality between districts that have common geological and topographical features, of a nature to affect the water-holding quality of the soil;

"(*b.*) by the existence of general disagreement between districts that are differently circumstanced in regard of such features; and

"(*c.*) by the discovery of pretty regular concomitancy in the fluctuation of the two conditions, from much phthisis with much wetness of soil to little phthisis with little wetness of soil.

"But the connection between wet soil and phthisis came out last year in another way, which must here be recalled—†

"(*d.*) by the observation that phthisis had been greatly reduced in towns where the water of the soil had been artificially

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* Report on the Distribution of Phthisis as affected by Dampness of Soil. *Tenth Report of the Med. Officer of the Privy Council* (for 1857), p. 57, 1868.

The geological points connected with this inquiry, and the general results obtained, have been fully stated by Mr. W. WHITAKER; "On the Connection of the Geological Structure and Physical Features of the South-east of England, with the Consumptive Death-rate."—*Geol. Mag.*, vol. vi. p. 499.

† This refers to a Report by DR. BUCHANAN, published in the preceding volume, upon the general sanitary improvements in England, particularly in large towns.

removed, and that it had not been reduced in other towns where the soil had not been dried.

"(5.) The whole of the foregoing conclusions combine into one—which may now be affirmed generally, and not only of particular districts—that *wetness of soil is a cause of phthisis to the population living upon it.*

"(6.) No other circumstance can be detected, after careful consideration of the materials accumulated during this year, that coincides on any large scale with the greater or less prevalence of phthisis, except the one condition of soil.

"(7.) In this year's inquiry, and in last year's also, single apparent exceptions to the general law have been detected. They are not altogether errors of fact or observation, but are indications of some other law in the background that we are not yet able to announce."

APPENDIX I.

LISTS OF FOSSILS.

(Revised by R. ETHERIDGE, F.R.S.)

The following tables are founded upon the lists, published or in MS., of the Geological Survey. These lists have been largely supplemented by reference to PROF. MORRIS' "Catalogue" and the Monographs of the Palæontographical Society. The general arrangement is that adopted by PROF. MORRIS. MR. DAVIDSON has kindly looked over and corrected the lists of the Brachiopoda; PROF. T. R. JONES has favoured me with MS. lists of the Foraminifera and Entomostraca.

TABLE I.—This is compiled almost entirely from the MS. lists of the Survey, from collections made by MR. C. GOULD, MR. J. C. COTTON, MR. R. ETHERIDGE, and myself. Some species from Poundsford are given on the authority of DR. MANTELL. MR. H. WILLETT and MR. J. E. H. PEYTON have aided in preparing the lists from Limekiln Wood.

TABLE II.—I am sorry to say that this is very incomplete. It is founded on the works of DR. MANTELL and DR. FITTON, and upon PROF. MORRIS' "Catalogue." The fauna and flora of the Weald still require careful study. MR. BECKLES has for many years largely collected from these strata, and in his museum there are abundant materials for working out this question.

TABLE III.—The fossils from the Atherfield Clay of Pease Marsh and Shalford are given mainly on the authority of MR. C. J. A. MEYER (On the Lower Greensand of Godalming." *Proc. Geol. Assoc.*, 1869). The lists from the Hythe Beds of Godalming are likewise on MR. MEYER's authority, and I have further to thank him for some MS. notes.* The fossils from the Atherfield Clay of Stopham and Redhill, the Hythe Beds of Pulborough, and the Sandgate Beds of Parham are chiefly from DR. FITTON's lists. The remainder of the fossils of the Wealden area are mainly from the Survey lists; those from the Hythe Beds of Lympne and Hythe have already been published in the Memoir on Sheet 4.

In the columns on the right-hand side I have given the distribution, in other districts, of Neocomian fossils which occur in the Wealden area. The lists from Speeton are taken from MR. JUDD's paper (*Quart. Journ. Geol. Soc.*, Vol. xxiv., pp. 218, 1868); those of the Isle of Wight are from MR. BRISTOW's Geological Survey "Memoir" on that area (1862); the lists from Farringdon are from PROF. MORRIS' "Catalogue" and PROF. PHILLIPS' "Geology of Oxford," 1871; that from Potton and Upware is chiefly from MR. WALKER's lists. In its stratigraphical relations the Lower Greensand of Potton and Upware appears to resemble the Phosphate Bed and the higher part of the Folkestone Beds of Folkestone; but the fossils (especially the Brachiopoda) will be seen to have a great similarity to those of the Pebble Beds of Godalming and Farringdon. The lists from the Blackdown Beds are mainly from PROF. MORRIS' "Catalogue" and from DR. FITTON; and upon the same authorities is given the list from Blackdown in Table IV. I have repeated this column because of the resemblance which the Blackdown fossils bear to both Upper and Lower Greensand and to the Gault; both Upper Cretaceous and Neocomian strata appear to be represented at Blackdown; but probably the division is less marked there than elsewhere.

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* It should be mentioned that the lists are grouped according to the Survey classification of the beds. MR. MEYER regards the Bargate Stone and Pebble Beds as the equivalent of the Folkestone Beds. The fossils in column No 10. he regards as partly from the Sandgate Beds and partly from the Hythe Beds. (See the Vertical Section given in the paper referred to above.)

TABLE IV.—The most important list in this Table is that of the Gault at Folkestone. A list of fossils from this place was given in the Memoir on Sheet 4; from this, and from his own collection, MR. C. E. DE RANCE kindly prepared a full list of fossils, which is incorporated in the present tables; a few additions have been made from MR. F. G. H. PRICE'S paper (*Quart. Journ. Geol. Soc.*, Vol. xxx., p. 342).

The Survey books have mainly supplied the lists from the Upper Greensand and Phosphate Bed of Folkestone.

The list of Upper Greensand fossils from Alton is taken from the Memoir on Sheet 12 (1862). The Gault and Upper Greensand fossils of Eastbourn are mainly from CHAMBERS' "Guide," 3rd ed. 1873 (the Geology by REV. E. S. DEWICK).

The Warminster lists are chiefly from PROF. MORRIS' "Catalogue" and PROF. PHILLIPS' "Geology of Oxford"; the lists from the Upper Greensand of Cambridge are from PROF. MORRIS and MR. SEELEY'S papers; the Upper Greensand and Chloritic Marl fossils of the Isle of Wight are from the Survey Memoir; the fossils of the Red Chalk (Hunstanton Limestone) are mainly from MR. WILTSHIRE'S paper (*Quart. Journ. Geol. Soc.*, Vol. xxv., p. 185), supplemented by reference to the papers of MR. JUDD and MR. SEELEY.

Other localities are mainly supplied from PROF. MORRIS' "Catalogue."

TABLE V.—This is by MR. C. E. DE RANCE, from collections made by him at Folkestone; some additional species are added from MR. PRICE'S paper.

× signifies that the locality is within the Wealden area.
o ,, ,, ,, without ,, ,,
Authors' names of admitted species are printed in Italics.
,, ,, synonyms ,, ,, ,, Roman type.
Synonyms are printed in Italics.

Only such synonyms are given as relate to the Wealden area, and even these are incomplete. The lists of fossils from localities outside the Wealden area are not complete lists for those localities; they are only intended to show the distribution, in some other districts, of fossils which occur in the Wealden area.

W. TOPLEY.

TABLE I. (OF APPENDIX I.).

FOSSILS OF THE PURBECK BEDS OF SUSSEX.

	Blues.	Between Blues and Greys.	Greys.					Also in the	
	Rounden Wood.	Limekiln Wood.	Poundsford.	Perch Hill.	Darvel Beach.	Limekiln Wood.	Copyhold Bridge.	Purbeck Beds, of Dorset.	Wealden Beds.
PLANTÆ.									
Wood	×	.	.	×	×	×	×		
Alethopteris elegans, *Dunker*	.	.	×						
Equisetites (*Equisetum*) Lyellii, *Mant.*	.	.	×	.	.	.	.	.	×
Sphenopteris Mantelli, *Brong.*	.	.	×	.	.	.	.	.	×
Hymenopteris psilotoides, Mant.									
CRUSTACEA.									
Cypridea leguminella, *Forbes*	?	.	.	.	.	.	.	o	×
" Valdensis, *Sow.*	×	.	.	×	×	×	×	o	
Cypris faba, Sow.									
" (?) sp. (not Valdensis)	.	.	.	.	.	×	×		
Estheria elliptica, *Dunker*	.	.	.	.	.	×	×	.	×
Cyclas subquadrata, Sow.									
MOLLUSCA.									
Lamellibranchiata.									
Corbula alata, *Sow.*	×	×	.	×	.	×	×	o	
Cyrena (*Cyclas*) angulata, *Sow.*	.	×	.	.	×	×	.	o	×
" elongata, *Sow.*	.	.	.	.	×	×	×	o	×
" gibbosa, *Sow.* (var. of *C. media.*)	.	.	.	.	×	×	×	o	×
" media, *Sow.*	×	?	×	×	×	×	×	o	×
" membranacea, *Sow.*	.	.	×	.	.	.	.	o	×
" parva, *Sow.*	.	.	×	×	×	×	×	o	
Modiola, new sp.	.	.	.	.	.	×			
" (?) sp.	.	×							
Mytilus Lyellii, *Sow.*	.	×	×	.	.	.	×		
Ostrea (?) sp.	.	×	×	×	.	.	×		
" a larger form	.	×							
Psammobia tellinoides, *Sow.*	.	.	×	.	.	.	.	o	
Tellina (?) sp.	.	×							
Unio (Species doubtful or not determined)	×	.	×	×	×	.	×		
Gasteropoda.									
Melanopsis (*Melania*) attenuata, *Sow.*	.	.	×	×	.	.	.	o	×
Cerithium carbonarium, Roemer.									
" harpæformis, *Dunker*	.	.	.	.	.	×	.	o	
" rugosa, *Dunker*	.	.	.	.	.	×			
" tricarinata, *Sow.*	.	.	×						
" (?) sp.	.	×	.	.	×				
Paludina (?) sp.	.	.	×	.	×	×			
Tornatella (*Actæon*) (*Melania*) Popei, *Sow.*	.	.	.	.	.	×	.	o	?
PISCES AND REPTILIA.									
Fish remains	.	.	.	.	×	×	×		
Hybodus dubius, *Ag.*	.	.	.	?	.	.	.	.	×
" (?) sp.	.	.	×						
Lepidotus Mantelli, *Ag.*	.	.	.	×	.	.	×	.	×
" (?) sp.	.	.	×						
Crocodilus	.	.	.	.	.	.	×		
Megalosaurus	.	.	×						
Bones (?) Turtle	.	.	.	.	.	×			
Coprolites	.	.	.	.	.	.	×		

TABLE II. (OF APPENDIX I.).

WEALDEN FOSSILS.

PLANTÆ.

Araucarites (*Zamiostrobus*) Pippingfordensis, *Ung.*	Ashdown Sand of Ashdown Forest.
Carpolithes Mantelli, *Brong.* - -	Tunb. Wells Sand of Tilgate Forest.
Clatharia Lyellii, *Mant.* - -	" " "
Endogenites erosa, *Mant.* - -	Ashdown Sand of Hastings.
Equisetites (*Equisetum*) Lyellii, *Mant.*	Hastings Beds, in many places.
Lonchopteris Mantelli, *Brong.* - *Pecopteris reticulata*, Mant.	Tunb. Wells Sand of Tilgate Forest.
Pterophyllum (*Cycadites*) Brongniarti, *Mant.*	Weald Clay of Heavers Wood Common.
Sphenopteris gracilis, *Fitton* - -	Hastings Beds of Tunbridge Wells.
S. Mantelli, *Brong.* - - - *Hymenopteris psilotoides*, Mant.	Tunb. Wells Sand of Tilgate Forest.
S. Phillipsii, *Mant.* - - -	Wealden Beds of Sussex.
S. Sillimani, *Mant.* - - -	Ashdown Sand of Heathfield.
Thuytes (*Cupressites*) Kurrianus, *Dunker.*	Hastings Beds of Hastings.
Zamiostrobus (*Zamia*) crassus, *Lind.*	Tunb. Wells Sand of Tilgate Forest.

CRUSTACEA.

Cypridea (*Cypris*) Fittoni, *Mant.* -	Generally distributed through the Wealden Beds.
C. granulosa, *Sow.* - - -	Top of Weald Clay at Hythe and Haslemere.
C. spinegera, *Sow.* - - -	" " " "
C. tuberculata, *Sow.* - - -	" " " "
C. Valdensis, *Sow.* - - - *Cypris faba*, Sow.	Generally distributed through the Wealden Beds.
Estheria elliptica, *Dunker* - - *Cyclas subquadrata*, Sow.	Tunbridge Wells; Ashdown Sand of Hastings, Bulverhithe, Winchelsea.

INSECTA.

Elytra of Coleoptera - - -	Weald Clay of Wateringbury; Fairlight Clays of Hastings.
Elytra of Neuroptera - - -	Fairlight Clays of Hastings.

MOLLUSCA.

Lamellibranchiata.

Corbula - - - -	Top of Weald Clay at Haslemere and Teston.
Cyrena (Cyclas) angulata, *Sow.* -	Generally distributed in the Wealden [Beds.
C. elongata, *Sow.* - - -	" " "
C. gibbosa, *Sow.* - - - (a var. of *C. media.*)	" " "
C. major, *Sow.* - - -	" " "
C. media, *Sow.* - - -	" " "
C. membranacea, *Sow.* - - -	" " "
Ostrea distorta, *Sow.* - - -	Top of Weald Clay at Hythe.
Mytilus - - - -	" " " Haslemere.
Unio* aduncus, *Sow.* - -	Bolney, Cuckfield.

* The Unionidæ of the Wealden Beds require further study. In this list I have given only the species and localities recorded by PROF. MORRIS in the 2nd ed. of his Catalogue. Unios of undetermined species are generally distributed through the Hastings Beds. In MR. S. H. BECKLES' collection, made chiefly in the neighbourhood of Hastings, there are ample materials for working out this question.

Unio antiquus, *Sow.* - - -	Pulborough, Tilgate Forest.
U. compressus, *Sow.* - - -	Tilgate Forest.
U. cordiformis, *Sow.* - - -	"
U. Gaulterii, *Sow.* - - -	Lenthington Green, near Tunbridge Wells.
U. Mantelli, *Sow.* - - -	Henhurst, Tilgate Forest.
U. Martini, *Sow.* - - -	" "
U. porrectus, *Sow.* - - -	" "
U. subtruncatus, *Sow.* - -	Tunbridge Wells.
U. Valdensis,* *Mant.* - -	

Gasteropoda.

Bulla Mantelliana, *Sow.* - -	Tilgate Forest.
Melanopsis (*Melania*) attenuata, *Sow.*	Hollington, near Hastings.
M. tricarinata, *Sow.* - - -	Top of Weald Clay at Haslemere.
Neritina Fittoni, *Mant.* - -	Tilgate Forest.
Paludina elongata, *Sow.* - -	Generally distributed through the Wealden Beds.
P. carinifera, *Sow.* - - -	Hastings, St. Leonard's, Hollington; Resting Oak Hill, near Lewes (and Purbeck Beds of Dorset).
P. fluviorum, *Sow.* - - - *P. vivipara*, Sow.	Generally distributed through the Wealden Beds.
P. Sussexiensis, *Mant.* - -	Weald Clay of Sussex.
Tornatella (*Actæon*) (*Melania*) Popei, *Sow.*	Recorded, by Dr. FITTON, from near Tunbridge Wells.

PISCES.

Acrodus Hirudo, *Ag.* - -	Tilgate Forest.†
Æchmodus (*Tetragonolepis*) mastodonteus, *Ag.*	Hastings.
Asteracanthus granulosus, *Eg.* -	Tilgate Forest.
Gyrodus Mantelli, *Ag.* - -	" "
Hybodus basanus, *Ag.* - -	Hastings.
H. dubius, *Ag.* - - -	Generally distributed through the Wealden Beds.
H. (*Sphenonchus*) elongatus, *Ag.* -	Tilgate Forest.
H. striatus, *Ag.* - - -	Tilgate Forest, Hastings.
H. subcarinatus, *Ag.* - -	" "
H. sulcatus,‡ *Ag.* - - -	
Lepidotus Fittoni, *Ag.* - -	Generally distributed through the Wealden Beds.
L. Mantelli, *Ag.* - - -	Tilgate Forest.
Oxyrhina paradoxa, *Ag.* - -	"
Pycnodus Mantelli, *Ag.* - -	"

REPTILIA.

Cetiosaurus brachyurus, *Ow.* -	Tetham.
C. brevis, *Ow.* - - -	Tilgate Forest, Battle.
Chelone costata, *Ow.* - - -	
C. Mantelli, *Fitzenger* - - *Chelone Bellii*, Mant.	Tilgate Forest.

* This is recorded only from the Isle of Wight, but in MR. BECKLES' collection there are specimens from Hastings which probably belong to this species.

† In the remainder of Table II., the age of the beds is not stated. Where the locality is *Hastings* or *St. Leonard's*, the age is doubtful; *Battle* is Wadhurst Clay; *Cuckfield* and *Tilgate Forest* are Tunbridge Wells Sand; *Bolney* is Weald Clay.

‡ Recorded as from the Chalk; but MR. MACKIE says that the specimen in the British Museum is not from the Chalk, it has fragments of Wealden grit adhering to it. (*Geologist*, vol. vi., p. 241.)

Coloborhynchus clavirostris, *Ow.* -	St. Leonard's.
Crocodilus - - - -	? Hastings.
Goniopholis crassidens, *Ow.* - -	Hastings, Battle (and Purbeck Beds of Dorset).
Hylæosaurus Owenii, *Mant.* - - *H. armatus*, Mant.	Tilgate Forest, Bolney, Battle.
Iguanodon Mantelli, *Meyer* - -	Tilgate Forest, Hastings, &c.
Megalosaurus Bucklandi, *Meyer* -	Cuckfield (and Stonesfield Slate).
Pelorosaurus (*Cetiosaurus*) Becklesii, *Mant.*	Hastings.
P. (*Cetiosaurus*) Conybeari, *Mant.* - *Cetiosaurus brachyurus*, Ow.	Tilgate Forest.
Platemys Dixoni, *Ow.* - -	,,
P. (*Emys*), Mantelli, *Ow.* -	,,
Pœcilopleuron Bucklandi, *Desl.* -	,,
Pterodactylus (*Palæornis*) Cliftii, *Mant.*	,, Hastings, Battle.
P. sagittirostris, *Ow.* - - -	St. Leonard's.
Regnosaurus (? *Hylæosaurus*) Northamptoni, *Mant.*	Tilgate Forest.
Streptospondylus (*Stenæosaurus*) major, *Ow.*	,,
Suchosaurus cultridens, *Ow.* -	,,
Tretosternon (*Trionyx*) Bakewelli, *Mant.*	,, (and Purbeck Beds, Swanage.)

TABLE III. (OF APPENDIX I.)—LOWER GREENSAND (UPPER NEOCOMIAN) FOSSILS OF THE WEALDEN AREA, WITH THEIR DISTRIBUTION IN OTHER DISTRICTS.

—	Atherfield Clay.						Hythe Beds.							Junction Bed.	Sandgate Beds.					Folkestone Beds.	Junction Bed.	Also in									
										Godalming.															Speeton.						
	Stopham.	Haslemere.	Pease Marsh and Shalford.	Redhill.	Sevenoaks.	Hythe.	Hythe.	Lympne.	Maidstone.	Below Pebble Beds.	Pebble Beds.	Bargate Stone.	Pulborough.	Great Chart	Folkestone Pier.	Sandgate.	Pulborough.	Parham.	Folkestone.	Folkestone.	Gault.	Upper Greensand.	Chalk.	Lower Neocomian.	Middle Neocomian.	Upper Neocomian.	Lower Greensand, Isle of Wight.	Lower Greensand, Farringdon.	Lower Greensand, Potton and Upware.	Blackdown Beds.
PLANTÆ.																															
Bennettites ? Leaf of	.	.	.	.	.	.	.	.	×																						
Chondrites fastigiatus, *Sternb.*	.	.	.	.	.	.	×	.	×	.	.	.	.	.	.	.	.	.	.	.	×	×	×								
Fucoides Bignoriensis, Mant.																															
" *Targioni*, Brong																															
Dracæna Benstedi, *Konig.*	.	.	.	.	.	.	.	.	×																						
Pinites (*Abietites*) Benstedi, *Mant.*	.	.	.	.	.	.	.	.	×																						
" Mantellii, *Carr.*	.	.	.	.	.	.	.	.	×																						
" patens, *Carr.*	.	.	.	.	.	.	.	.	×																						
" (*Zamia*) Sussexiensis,* *Mant.*																															
Coniferous Wood (bored by Pholades)	×	.	.	.	.	.	×	.	.		.	.	.	×	×	×	.	.	.	×											
Cone	.	.	.	.	.	.	×	.																							
INVERTEBRATA.—PROTOZOA.																															
Sponges	.	.	.	.	.	.	×	.	×	.	.	.	.	.	.	.	.	.	.	?											
Siphonia pyriformis, *Goldf.*	.	.	.	.	.	.	×	.	×	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	o	.	.	o	
Verticilites anastomosans, *Mant.*	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o		
ACTINOZOA.																															
Brachycyathus Orbignyanus, *Ed. & H.*	.	.	×																												
Chisma furcillatum, *Lonsdale*	.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o				
Holocystis (*Astrea*) (*Cyathophora*) elegans, *Lonsdale*	.	×	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o				
Isastrea Morrisii, *Duncan*	.	.	.	.	.	.	.	.	.	.	.	×																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Trochosmilia Meyeri, *Duncan*	.	.	.	.	.	.	.	.	.	.	.	×																		
ECHINODERMATA.																														
Cardiaster Benstedi, *Forbes*	.	.	.	.	.	.	×	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
,, ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×											
Catopygus (*Nucleolites*) carinatus, *Goldf.*	.	.	.	.	.	.	×	?	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o							
Cidaris	.	.	.	.	.	.	.	?	.	.	.	×																		
Discoidea subuculus, *Klein*	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×							
Echinus arenosus, *Sow.*	.	.	.	.	.	.	×	×																						
Hemipneustes Fittoni, *Forbes*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
Holaster ? sp.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?	.	.	.	.	.	.				
Peltastes Wrightii, *Desor*	.	.	.	.	.	.	×	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o		
Salenia punctata, Forbes																														
Pentacrinus Fittoni,† *Aust.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	×	o	×							
Pseudodiadema Malbosi, *Ag. & Desor*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
Diadema Mackesoni, Forbes																														
Salenia petalifera, *Desm.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	×							
S. personata, Forbes																														
Toxaster (*Hemipneustes*) (*Holaster*) complanatus, *Ag.*	.	.	×	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.	?				
Spines of Echinoderms	.	.	.	.	.	.	.	.	.	×	×																			
ANNELIDA.																														
Serpula antiquata, *Sow.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	×	o	×	.	o	o	o			
,, filiformis, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	×	.	.	.	.	.	.	.	o	.	.	o
,, variabilis, *Sow.*	.	.	.	.	.	.	×	×																						
,, ? sp.	.	.	×	.	.	.	.	.	.	.	×	×																		
Vermicularia (*Vermetus*) concava, *Sow.*‡	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	o	.	.	.	.	.	.	.	o
,, polygonalis, *Sow.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	×									
Vermilia (*Serpula*) ampullacea, *Sow.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	o
CIRRIPEDIA.																														
Pollicipes unguis, *Sow.*	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.			
P. lævis, Sow.																														
Pollicipes ? sp.	.	.	.	.	.	.	.	.	.	.	.	×																		
Scalpellum simplex, *Darwin*	.	.	.	.	.	.	.	.	×																					

* In the phosphate bed between the Gault and Lower Greensand at Selmeston (*see* p. 127). † "Lower Greensand" of Folkestone. ‡ Folkestone Beds of Pulborough.

TABLE III. (of Appendix I.)—Lower Greensand (Upper Neocomian)—*continued.*

—	Atherfield Clay.						Hythe Beds.							Junction Bed.	Sandgate Beds.				Folkestone Beds.	Junction Bed.	Also in									
										Godalming.														Speeton.						
	Stoham.	Haslemere.	Pense Marsh and Shalford.	Redhill.	Sevenoaks.	Hythe.	Hythe.	Lympne.	Maidstone.	Below Pebble Beds.	Pebble Beds.	Bargate Stone.	Pulborough.	Great Chart.	Folkestone Pier.	Sandgate.	Pulborough.	Parham.	Folkestone.	Folkestone.	Gault.	Upper Greensand.	Chalk.	Lower Neocomian.	Middle Neocomian.	Upper Neocomian.	Lower Greensand, Isle of Wight.	Lower Greensand, Farringdon.	Lower Greensand, Potton and Upware.	Blackdown Beds.
BRACHIOPODA.																														
Discina (a small striated species)	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×	.	.	.	.	.	.	.
Kingena lima,* *Defr.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o	.	.
Lingula truncata, *Sow.*	.	.	×	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.	.	.
Rhynchonella Cantabrigensis,* *Dav.*	.	.	.	.	.	.	.	×	.	.	.	.	.	.	×	×	.	.	×	.	.	.	.	.	.	.	o	o	o	.
" depressa,*† *Sow.*	.	.	.	.	.	.	×	×	.	.	.	.	.	×	×	×	×	.	×	.	.	.	.	‡	‡	‡	o	o	o	.
" elegans, *Sow.*	.	.	×	.	.	.	×	.	×	.	?	×	.	.	.	.	.	×	.	.	.	o	o	.	.	.	o	o	.	.
" Gibbsiana, *Sow.*	.	.	×	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o	.	.	.	o	o	o	.
" latissima, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Terebratula lata, Sow.																														
" nuciformis,† *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o	.	.	.	o	o	o	.
" parvirostris, *Sow.*	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.	o	.
" sulcata, *Park.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	o	.	.	.	.	.	.	.	.
Terebratella Davidsoni, *Walk.*	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.
" oblonga, *Sow.*	.	.	.	.	.	.	×	.	×	.	×	×	.	×	.	×	.	.	.	.	.	o	.	.	.	.	o	o	.	.
" Fittoni, *Meyer*	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.
" truncata, *Sow.*	.	.	.	.	×	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.	.
" trifida, *Meyer*	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?	?	.	.
Terebratula biplicata, *Sow.*§	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×	×	×	.	.	.	o	o	o	.
" depressa, *Lam.*	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	.	o	o	o	o	o	o	.
" extensa, *Meyer*	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.
" Meyeri, *Walk.*	.	.	.	.	.	.	.	.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.
" Moutoniana, *D'Orb.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o	.
" microtrema, *Walk.*	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o	o	.
" prælonga,* *Sow.*	.	.	.	.	.	.	×	×	×	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	o	o	.
" sella, *Sow.*	.	.	×	.	×	.	×	×	.	×	.	.	.	×	×	.	.	.	×	.	×	.	.	.	o	o	o	o	o	o
" Tornacensis, *D'Arch.*	.	.	.	.	.	.	.	.	.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o	?	.
Terebratulina elongata, *Dav.*	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.	.	.	.
" striata, *Wahl.*	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	o	.	o	.	o	.
Waldheimia (*Terebratula*) Celtica, *Rœmer*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Waldheimia Juddii, *Walk.*							×				×	×																o	o	
„ Morrisii, *Meyer*																											o			
„ pseudo-jurensis, *Leym.*											×								×									o	o	
„ tamarindus, *Sow.*							×			×	×	×															o	o	o	
„ Wanklyni, *Walk.*											×	×															o	o	o	
„ Woodwardi,‖ *Walk.*																													o	
LAMELLIBRANCHIATA.—*Monomyaria.*																														
Anomia (*Plicatula*) asperrima, *D'Orb.*			×																											
„ lævigata, *Sow.*			×				×	×																			o			
„ radiata, *Sow.*			×				×																				o			
Avicula Cottaldina, *D'Orb.*			×																											
„ depressa, *Forbes*			×																								o			
„ ephemera, *Forbes*			×																								o			
„ pectinata, *Sow.*							×					×							×								o			
„ Rauliniana, *D'Orb.*												×																		
Exogyra Ardennensis, *D'Orb.*							×																							
„ Boussingaultii, *D'Orb.*							×	×	×																		o			
Ostrea harpa, Goldf.																														
„ conica, *Sow.*							×							×						×	×	×	×				o	o		o
„ Couloni, *D'Orb.*			×																					o						
„ haliotoidea, *Lam.*								×				×									×	o								o
„ sinuata, *Sow.*		×		×			×	×	×										×						o	o	o			
„ subplicata, *Leym.*			×																											
„ Tombeckiana, *D'Orb.*			×							×	×	×																		
Gervillia (*Modiola*) alæformis, *Sow.*		×	×	×			×	×																			o			
„ anceps, *Desh.*		×	×	×			×	×	×				×	×	×	×		×									o			o
G. aviculoides, Sow.																														
„ solenoides, *Defr.*			×										×					×			×						o			
Hinnites Leymeriei, *Desh.*							×			×																	o			
Inoceramus concentricus, *Park.*																			×		×	×								o
„ gryphæoides, *Sow.*													×								×	o	×							
„ Neocomiensis, *D'Orb.*							×	×																			o			
„ Salamoni, *D'Orb.*																			×											
„ sulcatus, *Park.*																					×									o
„ ? sp.														×			×													
Lima Cottaldina, *D'Orb.*							×	×													×						o			
„ Dupiniana, *D'Orb.*							×																							
„ elongata, *Sow.*							×		×										×		×	×	×				o			
Modiola parallela, Sow.																														

* "Lower Greensand" of Godalming. † Folkestone Beds of Pulborough. ‡ See note * on page 473.

§ MR. DAVIDSON writes me (under date July 31st, 1874) that he very much doubts if *T. biplicata*, Sow., really occurs lower than the Gault. "Many specimens referred to *T. biplicata* from beds lower than the Gault belong to either *T. Cantabridgensis*, Walk., or to a variety of *T. sella*, Sow."

TABLE III. (of Appendix I.)—Lower Greensand (Upper Neocomian)—*continued.*

	Atherfield Clay.						Hythe Beds.								Sandgate Beds.																		
										Godalming.																	Also in Speeton.						
	Stopham.	Haslemere.	Pease Marsh and Shalford.	Redhill.	Sevenoaks.	Hythe.	Hythe.	Lympne.	Maidstone.	Below Pebble Beds.	Pebble Beds.	Bargate Stone.	Pulborough.	Great Chart. Junction Bed.	Folkestone Fier.	Sandgate.	Pulborough.	Parham.	Folkestone. Folkestone Beds.	Folkestone. Junction Bed.	Gault.	Upper Greensand.	Chalk.	Lower Neocomian.	Middle Neocomian.	Upper Neocomian.	Lower Greensand, Isle of Wight.	Lower Greensand, Farringdon.	Lower Greensand, Potton and Upware.	Blackdown Beds.
LAMELLIBRANCHIATA.—*Monomyaria*—cont.																																	
Lima expansa, *Forbes*	.	.	.	.	.	.		×		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		o			o
" lingua, *Forbes*	.	.	.	.	.	.	×			.	.	×	.	.	.	.	.	.	.	.	×	o	.	.	.	.					o
" semisulcata, *Sow.*	.	.	.	.	.	.																											
Ostrea (*Gryphæa*) canaliculata, *Sow.*	.	.	.	.	.	.																											
Exogyra undata, Sow.																																	
" flabella, *D'Orb.*	.	.	.	.	.	.		×																									
" frons, *Park.*	×	.	.	.	.	.	×			.	.	.	.	.	.	×	.	.	×	×	.	o	×	.	o	o	o	o			o
O. carinata, Sow.																																	
" Leymeriei, *Desh.*	.	.	×	.	×	.				.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o				
" macroptera, *Sow.*	.	.	.	.	.	.		×		×	.	×	.	.	.	.	.	.	.	.	o	×	.	.	.		o	o	o		
O. pectinata, Goldf.																																	
" ? sp.	.	×	.	.	.	.																											
Pecten Cottaldinus, *D'Orb.*	.	.	×	.	.	.				.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.					o	
" elongatus, *Lam.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	×	.	.	.	×	.	.	.						o
P. obliquus, Sow.																																	
" interstriatus, *Leym.*	.	.	×	×	.	×	×	×	.	.	.	×	.	.	.	.	.	.	×	.	.	o	.	.	.	o	o	o			
P. Dutemplei, D'Orb.																																	
P. Aptiensis, D'Orb.																																	
" orbicularis, *Sow.*	.	.	.	.	.	.				.	×	×	×	.	.	×	.	×	.	.	×	×	×	.	.	o	o				
P. lamellosus, Mant.																																	
" quadricostatus, *Sow.*	.	.	.	.	.	.				.	.	.	.	.	.	.	.	×	.	.	×	×									
" quinquecostatus, *Sow.*	.	.	×	.	.	.	×	×		.	.	.	.	×	.	×	.	.	×	.	×	×	×	.	.		o			o	
" Raulinianus, *D'Orb.*	.	.	.	.	.	.				.	×	×	.	.	.	.	.	.	.	.	×	.	.	.	.			o			
" Robinaldinus, *D'Orb.*	.	.	×	.	.	.				.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		o				
" Rhothomagensis, *D'Orb.*	.	.	.	.	.	.				.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.						
" striato-punctatus, *Rœmer*	.	.	×	.	.	.				.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	.	o					
" ? sp.	.	×	.	.	.	.	×	×	.																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Perna Mulleti, *Desh.*	.	×	×	×	×	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o			
Pinna crassa, *Sow.*	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
" Galliennei, *D'Orb.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.	.	.	.	o			
" Robinaldina, *D'Orb.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" sulcifera, *Desh.*	.	.	×	×	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	×	×	.	.	.	.	o	.	.	o
" tetragona, *Sow.*	.	×	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
" ? sp.	×																													
Plicatula Carterioniana, *D'Orb.*	.	.	.	.	.	.	.	.	×	×	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.	o	
" inflata, *Sow.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	×	.	.	.	.	.	×	×	.	.	.				
P. spinosa, Mant.																														
" plicunea, *Lam.*	.	.	.	.	.	.	×	×	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o			
Spondylus complanatus,* *D'Orb.*																														
Dimyaria.																														
Arca Carteroni, *D'Orb.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" consobrina, *D'Orb.*	.	.	×																											
" Cornueliana, *D'Orb.*	.	.	×	.	.	.	×	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.	.	o
" Dupiniana, *D'Orb.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" electra, *Nills.*	.	.	.	.	.	.	×																							
" Raulini, *Leym.*	×	×	×	×	×	×	×	.	.	.	.	.	×	.	.	.	.	.	×	.	×	×	.	.	.	.	o	.	.	o
" Robinaldina, *D'Orb.*	.	.	×																											
" securis, *Leym.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o			
" ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	×																
Astarte acuta, *D'Orb.*	.	.	×																											
" Beaumontii, *Leym.*	.	.	×	.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" laticosta, *Desh.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o	o				
" numismalis, *D'Orb.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" obovata, *Sow.*	.	.	×	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o	.	o
A. transversa, *D'Orb.*																														
" (*Venus*) striato-costata, *D'Orb.*	.	×	×	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" substriata, *Leym.*	.	.	×	×	.	.	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×															
Cardita (*Venus*) fenestrata, *Forbes*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
Cardium Austeni, *Forbes*	.	.	×	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" Benstedi, *Forbes*	.	.	.	.	.	.	.	.	×																					
" Cornuelianum, *D'Orb.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" Ibbetsoni, *Forbes*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" imbricatorium, *D'Orb.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	o			
" Raulinianum, *D'Orb.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" sphæroideum, *Forbes*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" subhillanum, *Leym.*	.	.	×	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" ? sp.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.				

* "Lower Greensand" of Folkestone.

TABLE III. (of Appendix I.)—Lower Greensand (Upper Neocomian)—*continued.*

—	Atherfield Clay.						Hythe Beds.							Junction Bed.	Sandgate Beds.				Folkestone Beds.	Junction Bed.	Also in									
									Godalming.															Speeton.						
	Stopham.	Haslemere.	Pease Marsh and Shalford.	Redhill.	Sevenoaks.	Hythe.	Hythe.	Lympne.	Maidstone.	Below Pebble Beds.	Pebble Beds.	Bargate Stone.	Pulborough.	Great Chart.	Folkestone Pier.	Sandgate.	Pulborough.	Parham.	Folkestone.	Folkestone.	Gault.	Upper Greensand.	Chalk.	Lower Neocomian.	Middle Neocomian.	Upper Neocomian.	Lower Greensand, Isle of Wight.	Lower Greensand, Farringdon.	Lower Greensand, Potton and Upware.	Blackdown Beds.
Dimyaria—cont.																														
Corbis (*Sphæra*) corrugata, *Sow.*	.	.	×	.	.	.	×	×	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	o			
Corbula elegans, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o
" striatula, *Sow.*	.	.	×	.	×	.	×	.	×	.	.	.	.	.	.	.	.	×	.	.	.	×	.	.	.	.	o			
" truncata, *Sow.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o
" ? sp.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Corimya (*Thracia*) carinifera, *D'Orb.*	.	.	.	.	.	.	.	×																						
" (*Thracea*) Nicoletii, *Ag.*	.	.	.	.	.	.	×																							
Crassatella Robinaldina, *D'Orb.*	.	.	.	.	.	.	×	×	×																					
" ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×															
Cucullæa Gabrielis, *Leym.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
Arca exaltata, Nils.																														
" glabra, *Park.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	×	o								
" ? sp.	×	.	×																											
Cyprina (*Venus*) angulata, *Flem.*	×	.	×	×	.	.	×	×	.	.	.	.	.	.	.	×	×	×	.	.	.	.	.	.	.	.	o	.	.	o
C. rostrata, Sow.																														
" cordiformis, *D'Orb.*	.	×																												
" ? sp.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×											
Cytherea (*Venus*) parva,* *Sow.*	.	.	×	.	.	.	.	.	.	.	.	.	.	×	.	.	.	×	.	.	×	.	.	.	.	.	o	.	.	o
Gastrochæna (*Fistulana*) dilatata, *Desh.*	.	.	×	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" (*Fistulana*) pyriformis, *Mant.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	×	×									
Isocardia similis,† *Sow.*																														
Leda (*Nucula*) scapha, *D'Orb.*	.	.	×	.	×	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
Lithodomus oblongus, *D'Orb.*	.	.	×	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
Lucina Arduenensis, *D'Orb.*	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×											
" Dupiniana, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	?	.	.	o	.	.	.	.	o			
" solidula, *Forbes*	.	.	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
? sp.	.	×	.	.	.	.	×																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Modiola æqualis, *Sow.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	o			
„ bella, *Sow.*	.	.	?	.	.	.	×	.	×	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
„ Carteroni, *D'Orb.*	.	.	×																											
„ lineata, *Sow.*	.	.	.	.	.	.	×	×																						
Myacites (*Panopæa*) rotundata, *Sow.*	.	.	.	.	.	.	.	×																						
Mytilus lanceolatus, *Sow.*	.	.	×	.	.	.	.	.	.	.	.	.	×	.	.	.	.	×	.	.	.	.	.	.	.	.	o	.	.	o
M. edentulus, Sow.																														
„ ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	×																
Nucula antiquata,* *Sow.*	.	.	×	.	.	.	.	?	.	.	.	.	×	.	.	.	.	×	.	.	.	.	.	.	.	.	o	.	.	o
„ Cornueliana, *D'Orb.*	.	.	×																											
„ impressa, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	o
„ obtusa, *Sow.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	o	o	.	.	o
N. planata, Desh.																														
„ ovata, *Mant.*	.	.	.	.	.	.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	×	o								
Panopæa (*Mya*) mandibula, *Sow.*	.	×	.	×	.	×	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	×	.	.	.	.	o			
„ Neocomiensis, *D'Orb.*	.	.	×	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	o	o	o	o			
„ plicata, *Sow.*	×	×	×	×	×	×	×	.	.	.	.	.	×	×	×	×	.	.	×	×	×	.	.	.	?	o	o			
Mya elongata, Rœmer																														
„ ? sp.	.	.	.	.	.	.	.	.	×																					
Pholadidea Cornuelianus, *D'Orb.*	.	.	.	.	.	.	×																							
„ (*Pholas*) prisca, *Sow.*	.	.	.	.	.	.	×	.	×	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	o			
„ ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×															
Pholadomya Agassizii, *D'Orb.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
„ (*Pholas*) gigantea, *Sow.*	.	.	.	.	.	.	×	×																						
„ Martini, *Forbes*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	o	o			
Solecurtus Warburtoni, *Forbes*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	o			
Tellina angulata, *Desh.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
„ inæqualis, *Sow.*	.	.	×	.	.	.	.	.	.	.	.	.	×	.	.	.	.	×	.	.	.	×	o	.	.	.	.	.	.	o
„ Vectiana, *Forbes*	.	.	×																								o			
Thetis Sowerbyi,‡ *D'Orb.*	.	.	×	.	.	.	×	.	.	.	.	.	×	×	×	×	×	×	×	.	×	×	.	.	.	o	o	.	.	o
T. minor, Sow.; *T. major*, Sow.																														
Trigonia alæformis,‡ *Park.*	.	.	.	.	.	.	×	×	×	.	.	.	×	×	.	×	×	×	×	.	.	.	.	.	.	.	o	.	.	o
„ carinata, *Ag.*	.	.	.	.	.	.	×	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
„ caudata, *Ag.*	×	×	×	.	×	.	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.	.	o
„ D'Archiaci, *D'Orb.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o								
„ dædalea, *Park.*	.	×	.	×	.	.	×	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	o	.	.	o
„ nodosa, *Sow.*	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
„ ornata, *D'Orb.*	.	.	×	.	.	.	×	×	×	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	o			
„ rudis, *Park.*	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
T. spectabilis, Sow.																														
„ spinosa, *Park.*	.	.	.	.	.	.	×	×	×	.	.	.	×	.	.	.	.	.	.	.	.	o	.	.	.	?	o	.	o	o
Venus Brongniatiana, *Leym.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
„ faba, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	o
„ ovalis, *Sow.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×	.	.	.	.	.	.	.	.	o			
„ Orbigniana, *Forbes*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
„ Vectensis, *Forbes*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			

* Folkestone Beds of Pulborough. † "Lower Greensand" of Sandgate. ‡ Folkestone Beds of Maidstone.

TABLE III. (of Appendix I.)—Lower Greensand (Upper Neocomian)—*continued.*

—	Atherfield Clay.						Hythe Beds.							Junction Bed.	Sandgate Beds.				Folkestone Beds.	Junction Bed.	Also in										
										Godalming														Speeton.							
	Stoplnm.	Haslemere.	Pease Marsh and Shalford.	Redhill.	Sevenoaks.	Hythe.	Hythe.	Lympne.	Maidstone.	Below Pebble Beds.	Pebble Beds.	Bargate Stone.	Pulborough.	Great Chart.	Folkestone Pier.	Sandgate.	Pulborough.	Parham.	Folkestone.	Folkestone.	Gault.	Upper Greensand.	Chalk.	Lower Neocomian.	Middle Neocomian.	Upper Neocomian.	Lower Greensand, Isle of Wight.	Lower Greensand, Farringdon.	Lower Greensand, Potton and Upware.	Blackdown Beds.
GASTEROPODA.																															
Actæon affinis, *Sow.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	o	.	.	o
" (*Tornatella*) elongatus, *Sow.*	.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.
" (*Auricula*) marginatus, *D'Orb.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.	.	.
Aporrhais (*Rostellaria*) calcarata, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	×	.	.	.	.	.	.	.	.	o
" (*Rostellaria*) glabra, *Forbes*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.	.	.
" (*Rostellaria*) macrostoma, *Sow.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o
" (*Rostellaria*) Robinaldina, *D'Orb.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	.	.	.
Avellana globulosa, *D'Orb.*	.	.	×																											o
" incrassata, *Mant.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	
Cerithium Albensis, *D'Orb.*	.	.	×																											
" Dupinianum, *D'Orb.*	.	.	×																											
" Marrollinum, *D'Orb.*	.	.	×																											
" Neocomiense, *D'Orb.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" Phillipsii, *Leym.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?	.	o			
" turriculatum, *Forbes*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" ? sp.	.	×																												
Dentalium ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×															
Emarginula Neocomiense, *D'Orb.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o			
Eulima Albensis, *D'Orb.*	.	.	×																											
Fissurella ? sp.	.	.	×																											
Fusus Neocomiensis, *D'Orb.*	.	.	×																											
Natica (*Littorina*) (*Turbo*) rotundata, *Sow.*	.	.	×	.	.	.	×	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	o			
Natica ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	×																
Neritopsis Robineausiana, *D'Orb.*	.	.	×																											
Periploma Robinaldina, *D'Orb.*	.	.	.	.	.	.	×																							
Phasianella ? sp.	.	.	×																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Pleurotomaria Anstedi,* *Forbes*	×	.	.	.	.	.	×	×																						
" (*Trochus*) gigantea,† *Sow.* *P. striata*, Sow.																														
" Neocomiensis, *D'Orb.*	.	.	×																											
" perspectiva, *Mant.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×							
Pterocera Fittoni, *Forbes*	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" Moreausiana, *D'Orb.* *P. Becklesi*, Mant.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
Rostellaria ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×													
Scalaria (*Melanopsis*) Clementina, *Mich.*	.	.	.	.	.	.	‡	.	.	.	.	.	.	.	.	.	.	.	.	.	×									
" (allied to S. Dupiniana, *D'Orb.*)	.	.	×																											
Solarium Benstedi, *Forbes*	.	.	.	.	.	.	.	.	×																					
Trochus Albensis, *D'Orb.*	.	.	×																											
" decussatus, *Leym.*	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	o									
Turbo munitus, *Forbes*	.	.	×																											
" Yonnianus, *D'Orb.*	.	.	.	.	.	.	.	.	×																					
Turritella granulata, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	×	.	.	.	o	.	.	.	.	.	.	.	o
" ? sp.	.	×																												
CEPHALOPODA.																														
Ammonites Beudantii, *Brong.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×									
" Carteroni,* *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" Cornuelianus, *D'Orb.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" Deshayesii, *Leym.*	.	.	.	.	.	×	×	×	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	o	o			
" furcatus, *Sow.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" Hambrovii, *Forbes*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" interruptus, *D'Orb.* *A. dentatus*, Sow.; *A. serratus*, Park.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×								
" mammilaris, *Schloth.* *A. monile*, Sow.	.	.	.	.	.	.	?	.	.	.	.	.	.	.	.	.	.	.	×											
" Martini, *D'Orb.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" Nutfieldensis,* *Sow.*	.	.	.	.	.	.	×	.	.	.	.	×	×																	
" recticostatus, *D'Orb.*	.	.	.	.	.	.	?																							
" ? sp.	.	.	×	.	.	.	.	.	.	×	.	×	.																	
Ancyloceras (*Scaphites*) gigas, *Sow.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
" (*Hamites*) grande,¶ *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o				
" (*Scaphites*) Hillsii, *Sow.*	.	.	.	.	.	.	×																							
" ? sp.	.	.	.	.	.	.	.	.	.	×																				
Belemnitella plena, *Blainv.* *B. lanceolatus*, Sow.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×							
Belemnites jaculum, *Phil.*	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	o	o					
" semicanaliculatus, *Blainv.*	.	.	.	.	.	.	×	×																						
" ? sp.	.	.	.	.	.	.	.	.	×	×																				

" Lower Greensand " of Nutfield.
† Lower Greensand (Hythe Beds) of Boughton.
‡ Hythe Beds, near Sandgate.
¶ "Lower Greensand " of Smeeth, near Ashford.

TABLE III. (of Appendix I.)—Lower Greensand (Upper Neocomian)—*continued.*

—	Atherfield Clay.						Hythe Beds.							Junction Bed.	Sandgate Beds.				Folkestone Beds.	Junction Bed.	Also in									
										Godalming.														Speeton.						
	Stopham.	Haslemere.	Pease Marsh and Shalford.	Redhill.	Sevenoaks.	Hythe.	Hythe.	Lympne.	Maidstone.	Below Pebble Beds.	Pebble Beds.	Bargate Stone.	Pulborough.	Great Chart.	Folkestone Pier.	Sandgate.	Pulborough.	Parham.	Folkestone.	Folkestone.	Gault.	Upper Greensand.	Chalk.	Lower Neocomian.	Middle Neocomian.	Upper Neocomian.	Lower Greensand, Isle of Wight.	Lower Greensand, Farringdon.	Lower Greensand, Potton and Upware.	Blackdown Beds.
CEPHALOPODA—*continued.*																														
Crioceras (Tropæum) Bowerbankii, *Sow.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
Hamites nodosus, *Sow.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.				
" ? sp.	.	.	.	.	.	×	×	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Nautilus elegans, *Sow.*	.	.	.	.	.	.	×	.	×	.	.	.	.	.	.	.	.	.	.	.	.	×	×							
" inæqualis,* *Sow.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	.							
" Neocomiensis,† *D'Orb.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?	.	.	.	o			
" plicatus, *Fitton*	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o				
" pseudo-elegans, *D'Orb.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	.	.	o	o			
" radiatus, *Sow.*	×	.	.	×	.	.	×	.	.	.	.	×	.	.	.	×	.	.	.	.	.	.	×	.	.	o	o			
" undulatus,‡ *Sow.*	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o							
VERTEBRATA.—PISCES.																														
Lepidotus	.	.	.	.	.	.	.	.	.	.	?																			
Ischyodus (*Chimæra*) Agassizi, *Buckl.*	.	.	.	.	.	.	.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	×							
Strophodus sulcatus, *Ag.*	.	.	.	.	.	.	.	.	×																					
REPTILIA.																														
Ichthyosaurus campylodon, *Carter*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	×	o	×							
Iguanodon Mantelli, *Meyer*	.	.	.	.	.	.	.	.	×	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o			
Plesiosaurus latispinus, *Ow.*	.	.	.	.	.	.	.	.	×																					
Polyptychodon continuus, *Ow.*	.	.	.	.	.	.	×	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	×							
Protemys serrata, *Ow.*	.	.	.	.	.	.	.	.	×																					

* "Lower Greensand" of Folkestone. † "Lower Greensand" of Surrey. ‡ "Lower Greensand" of Nutfield.

TABLE IV. (OF APPENDIX I.).

UPPER GREENSAND AND GAULT FOSSILS OF THE WEALDEN AREA, WITH THEIR DISTRIBUTION IN OTHER DISTRICTS.

—	Upper Greensand.							Gault.						Junction Bed.	Also in			
					Also at													
	Eastbourn.	Petersfield and Selbourne.	Alton.	Folkestone.	Warminster.	Upper Greensand and Chloritic Marl, Isle of Wight.	Cambridge.	Eastbourn.	Ringmer and Hamsey.	Bletchingley.	West Malling.	Aylesford and Maidstone.	Folkestone.	Folkestone.	Lower Greensand.	Blackdown Beds.	Hunstanton Limestone.	Chalk.
PLANTÆ.																		
Chondrites fastigiatus,* *Sternb.* *Fucoides Bignoriensis*, Mant. *Fucoides Targioni*, Brong.	.	.	.	.	.	o	.	.	.	.	.	.	×	.	×	.	.	×
Pinites gracilis, *Carr.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" hexagonus, *Carr.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" (*Zamia*) Sussexiensis,† *Mant.*																		
Sequoiites Gardneri, *Carr.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" ovalis, *Carr.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Wood (bored by Lithodomi)	.	.	.	.	.	.	.	.	.	.	.	.	.	×				
PROTOZOA.																		
Brachiolites (*Spongia*) labyrinthicus, *Mant.*	×	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	×
Choanites ? sp.	.	.	×	×	.	.	.	.	.	.	.	.	×					
Cliona ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	×				
Siphonia pyriformis, *Goldf.*	×	.	.	.	o	o	.	.	.	.	.	.	.	.	×	o	o	
FORAMINIFERA.																		
Bulimina (*Ataxophragmium.*) D'Orbignyi, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" obliqua, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	‡	.	.	.	.	§
" obtusa, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	‡	.	.	.	.	§
" (*Ataxophragmium.*) Presli, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	×
Cristellaria acuta, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" complanata, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" exilis, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" lævigata, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" obsoleta,‖ *Jones*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×
" oligostegia, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" rotulata, *Lam.*	.	.	.	.	.	.	.	.	.	.	.	.	‡	.	.	.	.	§
" subulata, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" sulcifera, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" triangularis, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	¶	.	.	.	.	×
Dentalina catenula, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" communis, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	‡	.	.	.	.	§
" gracilis, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	‡	.	.	.	.	§
" legumen, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" sorora, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" sulcata, *Nilsson*	.	.	.	.	.	.	.	.	.	.	.	.	‡	.	.	.	.	
Flabellina cordata, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	¶	.	.	.	.	×

* Upper Greensand of Bignor.
† In the phosphatic bed between the Gault and Lower Greensand at Selmeston, Sussex. (*See* p. 127.)
‡ Gault of England, probably Folkestone.
‖ Gault near Charing, Kent.
§ Chalk of England.
¶ Gault of Kent, probably Folkestone.

TABLE IV. (of Appendix I.)—Upper Greensand and Gault Fossils of the Wealden Area—*cont.*

—	Upper Greensand.							Gault.						Junction Bed.	Also in			
					Also at													
	Eastbourn.	Petersfield and Selbourne.	Alton.	Folkestone.	Warminster.	Upper Greensand and Chloritic Marl, Isle of Wight.	Cambridge.	Eastbourn.	Ringmer and Hamsey.	Bletchingley.	West Malling.	Aylesford and Maidstone.	Folkestone.	Folkestone.	Lower Greensand.	Blackdown Beds.	Hunstanton Limestone.	Chalk.
FORAMINIFERA—*cont.*																		
Frondicularia Cordai, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	×
" inversa, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" microdisca, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Parkeri, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Gaudryina pupoides, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	†	.	.	.	.	‡
Glandulina mutabilis, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Globigerina bulloides, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	§	.	.	.	.	.	×
" cretacea,¶ *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×
Lingulina semiornata, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Lituola (*Haplophragmium*) nonionoides, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Marginulina tenuissima, *var., Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Miliola, ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	‡
Nodosaria Jonesi, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" lamellicostata, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" obscura, *Reuss*	.	.	.	.	o	.	.	.	.	.	.	.	†	.	.	.	.	‡
" orthopleura, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Planorbulina Ungeriana, *D'Orb.*	.	.	.	.	o	.	.	.	.	.	.	.	*	.	.	.	.	×
Planorbulina (*Anomalina*) ammonoides, *Reuss*	.	.	.	.	o	.	.	.	.	.	.	.	†	.	.	.	.	‡
Planorbulina (*Truncatulina*) variabilis, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	*					
Planorbulina (*Truncatulina*) lobatula, *W. & J.*	.	.	.	.	o	.	.	.	.	.	.	.	*	.	.	.	.	×
Pulvinulina Carpenteri, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" caracolla, *Rœmer*	.	.	.	.	o	.	.	.	.	.	.	.	×					
" spinulifera, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Rhabdogonium excavatum, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Trochammina cretacea, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	†	.	.	.	.	‡
Textilaria agglutinans, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	†	.	.	.	.	‡
" concinna, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" gibbosa, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	†	.	.	.	.	‡
Vaginulina arguta, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" costulata, *Rœmer*	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	×
" eurynota, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" protosphæra, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" recta, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" strigilata, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	*					
" transversalis, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Verneuilina (*Tritaxia*) pyramidata, *Reuss*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Verneuilina triquetra, *Münster* *V. tricarinata*, D'Orb.	.	.	.	.	.	.	.	.	.	.	.	.	†	.	.	.	.	‡
ACTINOZOA.																		
Bathycyathus Sowerbyi, *Ed. & H.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Caryophillia (*Cyathina*) Bowerbankii, *Ed. & H.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Cyclocyathus Fittoni, *Ed. & H.*	.	.	.	.	.	.	.	.	.	.	.	.	×	×	×			
Leptocyathus gracilis, *Duncan.*	.	.	.	.	.	.	.	.	.	.	.	.	×					

* Gault of Kent, probably Folkestone.
‡ Chalk of England.
¶ Gault of Leacon Hill, near Charing.
† Gault of England, probably Folkestone.
§ Gault of Burham.

TABLE IV. (of Appendix I.)—Upper Greensand and Gault Fossils of the Wealden Area—*cont.*

—	Upper Greensand.				Also at			Gault.						Junction Bed.	Also in			
	Eastbourn.	Petersfield and Selbourne.	Alton.	Folkestone.	Warminster.	Upper Greensand and Chloritic Marl, Isle of Wight.	Cambridge.	Eastbourn.	Ringmer and Hamsey.	Bletchingley.	West Malling.	Aylesford and Maidstone.	Folkestone.	Folkestone.	Lower Greensand.	Blackdown Beds.	Hunstanton Limestone.	Chalk.
(*Actinozoa*)—cont.																		
Micrabacia coronula, *Goldf.* - *Turbinolia Konigi*, Mant.	.	.	.	.	o	.	o	.	.	×	.	.	×	.	.	.	o	
Micrabacia Fittoni, *Duncan* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Parasmilia, *sp. nov.* ? - -	.	.	.	.	.	.	.	.	.	.	.	.	?					
Smilotrochus cylindricus, *Duncan*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Smilotrochus elongatus, *Duncan*	.	.	.	.	.	.	o	.	.	.	.	.	×					
Smilotrochus granulatus, *Duncan*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Smilotrochus insignis, *Duncan*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Trochocyathus consulus, *Phil.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Harveyanus, * *Ed. & H.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Wiltshirei, *Duncan*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Trochosmilia sulcata, *Ed. & H.*	.	.	.	.	.	.	.	.	.	.	.	.	×	×				
ECHINODERMATA.																		
Ananchytes (*Holaster*) lævis, *De Luc.*	?	×	×	.	o	o												
Cardiaster (*Spatangus*) fossarius, *Benett.*	.	×	×	.	o													
Cidaris Gaultina, *Forbes* -	.	.	.	.	.	.	.	×	.	.	.	.	×	.	.	.	o	
Discoidea subuculus, *Klein* -	×	.	.	.	o	o	.	.	.	.	.	.	.	.	×	.	.	×
Goniaster - - -	×	.	.	.	.	.	.	.	.	.	.	.	×					
Hemiaster asterias, *Forbes* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Baileyi, *Forbes* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" minimus, *Ag.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Holaster (*Ananchytes*) subglobosus,† *Leske*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×
Pentacrinus Fittoni, *Aust.* -	.	.	.	.	o	.	.	.	.	.	.	×	×	×	×	.	o	×
" ? sp. - -	×																	
Pseudodiadema ornata, *Goldf.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	o	o
" Wiltshirei, *Wright*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Stellaster elegans, *Gray* -	.	.	.	×	.	.	.	.	.	.	.	.	.	.		o		
ANNELIDA.																		
Serpula antiquata, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×	.	o	×
" articulata, *Sow.* -	.	.	.	×	.	.	.	.	.	.	.	.	×	.	o			
" filiformis, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	o		
" plexus, *Sow.* - -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" rustica, *Sow.* - -	.	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	o	
Vermicularia (Vermetus) umbonata, *Mant.*	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	o	×
Vermicularia polygonalis, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×			
CIRRIPEDIA.																		
Pollicipes politus, *Darwin* -	.	.	.	.	.	.	.	.	.	.	.	.	?					
" rigidus, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	×	×					
" unguis, *Sow.* - *P. lævis*, Sow.	.	.	.	.		.	.	×	.	.	.	×	×	.	×	o	o	.
Scalpellum arcuatum, *Darwin*	.	.	.	.		.	.	.	.	.	.	.	×	.	.	.	.	×

* PROF. DUNCAN recognises five varieties of this species, all of which are from the Gault of Folkestone.

† Junction of Chalk Marl and Upper Greensand at Abinger.

TABLE IV. (of Appendix I.)—Upper Greensand and Gault Fossils of the Wealden Area—*cont.*

	Upper Greensand.							Gault.						Junction Bed.	Also in			
					Also at													
	Eastbourn.	Petersfield and Selbourne.	Alton.	Folkestone.	Warminster.	Upper Greensand and Chloritic Marl, Isle of Wight.	Cambridge.	Eastbourn.	Ringmer and Hamsay.	Bletchingley.	West Malling.	Aylesford and Maidstone.	Folkestone.	Folkestone.	Lower Greensand.	Blackdown Beds.	Hunstanton Limestone.	Chalk.
CRUSTACEA.																		
Bairdia Harrisiana,* *Jones*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×
Cythere concentrica,* *Reuss*	.	.	.	.	o	.	.	.	.	.	.	.	×	.	†	.	.	×
C. punctatula, Jones *non* Rœmer																		
" (*Cythereis*) Gaultina,* *Jones*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" (*Cythereis*) Harrisiana,* *Jones*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×			
Cythereis interrupta, Jones *non* Bosquet																		
" (*Cythereis*) ornatissima,* *Reuss.*	.	.	.	.	o	.	.	.	.	.	.	.	×	.	.	.	.	×
Cythereis ciliata, Jones *non* Reuss																		
" (*Cythereis*) ornatissima, *Reuss* Var. cornuta, *Jones*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	×
" *Cythereis cornuta*, Jones *non* Rœmer																		
" (*Cythereis*) quadrilatera,* *Rœmer*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	†	.	.	×
" (*Cythereis*) triplicata,* *Rœmer*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	†	.	.	×
Cytherella Muensteri,* *Rœmer*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	×
C. truncata, Bosquet																		
" ovata,* *Rœmer*	.	.	.	.	o	.	.	.	.	.	.	.	×	.	†	.	o	×
" Williamsoniana,* *Jones*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	×
Cytheridea perforata,* *Rœmer*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o	.	×
Cythere Hilseana, Jones *non* Rœmer																		
Cytheridea Jonesiana, Bosquet																		
Cytherideis (*Bairdia*) angusta, *Münster*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	×
Cytherura (*Cytherella*) appendiculata, *Jones*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Diaulax feliceps, *Woodw.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Carterianа, *Bell.*	.	.	.	.	.	.	o	.	.	.	.	.	×					
Enoploclytia (*Astacus*) ? sp.	×	.	.	.	.	.	.	.	.	.	.	.	×					
Etyus Martini, *Mant.*	.	.	.	.	.	.	o	.	×	.	.	×	×					
Reussia granosa, McCoy																		
Homolopsis Edwardsii, *Bell*	.	.	.	.	.	.	o	.	.	.	.	.	×					
Hoploparia ‡ (*Astacus*) longimana, *Sow.*	.	.	.	.	.	.	o	.	.	.	.	.	×					
" scabra, *Bell*	.	.	.	.	.	.	o	.	.	.	.	.	×					
" sulcirostris, *Bell*	.	.	.	.	.	.	o	.	.	.	.	.	×					
Orthiopsis Bonneyi, *Carter*	.	.	.	.	.	.	o	.	.	.	.	.	×					
Necrocarcinus tricarinatus, Bell																		
Mesocrangon atra, *Woodw.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Necrocarcinus (*Adelia*) (*Notopocorystes*) Bechei, *Deslong.*	.	.	.	.	o	.	o	.	×	.	.	.	×					
Arcania Bucklandii, Mant.																		
Palæocorystes (*Corystes*) (*Notopocorystes*) Broderipii, *Mant.*	.	.	.	.	.	.	.	.	×	.	.	×	×					
Palæocorystes (*Corystes*) Stokesii, *Mant.*	.	.	.	.	.	.	o	.	×	.	.	o	×					
Notopocorystes Mantelli, McCoy																		
Scyllaridia Gardneri, *Woodw.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" punctata, *Woodw.*	.	.	.	.	.	.	.	.	.	.	.	.	×					

* Gault of Leacon Hill, near Charing. † Lower Greensand of France.

‡ *Hoploparia punctulata*, Bell, is recorded from the Gault by PROF. BELL, but no locality is given.

TABLE IV. (of Appendix I.)—Upper Greensand and Gault Fossils of the Wealden Area—*cont.*

—	Upper Greensand.							Gault.						Junction Bed.	Also in			
					Also at													
	Eastbourn.	Petersfield and Selbourne.	Alton.	Folkestone.	Warminster.	Upper Greensand and Chloritic Marl, Isle of Wight.	Cambridge.	Eastbourn.	Ringmer and Hamsey.	Bletchingley.	West Malling.	Aylesford and Maidstone.	Folkestone.	Folkestone.	Lower Greensand.	Blackdown Beds.	Hunstanton Limestone.	Chalk.
BRACHIOPODA.																		
Kingena lima, *Defr.*	×	.	.	.	o	.	o	.	.	.	.	.	×	.	×	.	o	×
Rhynchonella Grasiana, *D'Orb.*	.	.	.	×	o	o												
" Martini, *Mant.*	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×
" sulcata, *Park.*	.	.	.	.	o	.	o	?	.	.	.	.	×	×	*	.	o	
Terebratula biplicata, *Sow.*	×	.	.	.	o	o	o	×	.	.	.	.	×	.	×	.	o	o
" sella, *Sow.*	.	.	.	.	.	o	.	.	.	.	.	×	.	.	×			
Terebratulina gracilis, *Schloth.*	×	.	.	.	.	.	o	.	.	.	.	.	.	.		.	o	×
LAMELLIBRANCHIATA.																		
Monomyaria.																		
Anomia ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	×					
Avicula Cenomanensis, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" gryphæoides, *Sow.*	×	×	.	.	.	.	.	.	.	.	.	.	×	.	.	.	o	
" ? sp.	.	.	.	.	.	.	.	×										
Exogyra conica, *Sow.*	.	.	×	×	o	o	o	×	.	.	.	.	×	×	×	o	o	×
" columba, *Lam.*	.	×	.	×														
" haliotoidea, *Lam.*	.	.	.	.	o	o	.	.	.	.	.	.	×	.	×	o	o	
Gervillia solenoides, *Defr.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×			
Inoceramus concentricus, *Park.*	.	.	×	.	o	o	.	×	.	×	×	×	×	×	×	o	o	
" Crispii, *Mant.*	.	.	.	?	.	.	.	.	×	.	.	.	×	.	.	.	o	×
" gryphæoides, *Sow.*	.	.	.	.	.	.	.	.	×	.	.	?	.	.	×	.	.	×
" subsulcatus, *Wiltshire*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" sulcatus, *Park.*	.	.	.	.	.	.	.	×	×	×	×	×	×	?	?	o	o	
Lima Cottaldina, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×			
" elongata, *Sow.*	×	×	×	×	.	o	.	.	.	.	.	.	×	.	×	.	.	×
Modiola parallela, Sow.																		
" globosa,† *Sow.*	.	.	.	.	.	.	o	.	.	.	.	.	×	.	.	.	.	×
" (*Plagiostoma*) Hoperi, *Sow.*	×	.	×	.	.	o	.	?	.	.	.	.	.	.	.	.	.	×
Ostrea canaliculata, *Sow.*	.	.	.	.	o	.	.	.	.	.	.	.	×	.	×	o		
" frons, *Park.*	×	.	.	×	o	o	.	.	.	.	.	.	×	×	×	o		
O. carinata, Sow.																		
" macroptera, *Sow.*	.	.	×	.	.	.	o	.	.	.	.	.	.	.	×			
" Normaniana, *D'Orb.*	×	.	.	.	o	.	.	.	.	.	.	.	.	.	.	.	.	×
" vesicularis, *Lam.*	×	.	.	.	o	.	.	?	.	.	.	.	.	.	o	.	o	×
Pecten asper, *Lam.*	.	×	×	.	o	o	.	.	.	.	.	.	.	.	.	o		
" Beaveri, *Sow.*	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	×
P. obliquus, Sow.																		
" elongatus, *Lam.*	.	.	×	.	o	o	.	.	.	.	.	.	.	.	×	o		
" nitidus, *Mant.*	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×
" orbicularis, *Sow.*	×	×	×	×	o	o	.	×	.	.	.	.	×	.	×	.	.	×
" quadricostatus, *Sow.*	.	.	×	.	o	o	.	.	.	.	.	.	×	.	×			
" quinquecostatus, *Sow.*	×	×	×	×	o	o	.	×	.	.	.	.	×	.	×	o	.	×
" Raulinianus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×			
" striato-punctatus, *Rœmer*	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×			
Perna Rauliniana, *D'Orb.*	.	.	.	.	.	.	o	.	.	.	.	.	×					
" Ricordiana, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	o			
Pinna tetragona, *Sow.*	.	.	×	.	.	o	.	.	.	.	.	.	×	.	×			
" ? sp.	.	.	.	.	.	.	.	.	×							o		

* There has been much confusion as regards this species and *R. Gibbsiana*, Sow. *R. sulcata* is now regarded as exclusively an Upper Cretaceous form. It has been recorded by MR. JUDD from each division of the Neocomian of Speeton; but MR. DAVIDSON, in whose Monograph this name had appeared, now informs me that the Speeton shells are probably referable to *R. multiformis*, Rœmer, a form which is very abundant in the Neocomian of the Continent.—W. T.

† Upper Greensand of Sussex.

TABLE IV. (of Appendix I.)—Upper Greensand and Gault Fossils of the Wealden Area—*cont.*

	Upper Greensand.							Gault.						Junction Bed.	Also in			
					Also at													
	Eastbourn.	Petersfield and Selbourne.	Alton.	Folkestone.	Warminster.	Upper Greensand and Chlorite Marl, Isle of Wight.	Cambridge.	Eastbourn.	Ringmer and Hamsey.	Bletchingley.	West Malling.	Aylesford and Maidstone.	Folkestone.	Folkestone.	Lower Greensand.	Blackdown Beds.	Hunstanton Limestone.	Chalk.
LAMELLIBRANCHIATA—*cont.*																		
Monomyaria—cont.																		
Plicatula inflata, *Sow.* -	×	×	×	.	o	o	.	.	.	.	.	.	.	.	×	.	.	×
P. spinosa, Mant.																		
" pectinoides, *Sow.* -	×	.	×	.	.	.	o	×	.	.	.	.	×	×	?	.	.	
P. radiola, Lam.																		
Spondylus (*Dianchora*) latus, *Sow.*	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o	×
" (*Dianchora*) striatus, *Sow.*	.	×	×	.	o	o	o	.	.	.	.	.	.	.	o	o	o	×
Dimyaria.																		
Astarte Dupiniana, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Arca (*Cucullæa*) carinata, *Sow.*	.	.	×	.	.	o	.	.	.	.	.	.	×	.	.	o		
Arca (*Cucullæa*) Hugardiana, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Arca (*Cucullæa*) Raulini, *Leym.*	.	×	×	.	.	.	.	.	.	.	.	.	×	.	×	o		
Arca, ? sp. - - -	.	.	.	.	.	.	.	.	.	.	.	.	.	×				
Cardita rotundata, *Pict.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" tenuicosta, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Cardium gentianum, *Sow.* -	.	×	.	.	.	o												
Cardita tuberculata, Sow.																		
Cardium, ? sp. - - -	×	×																
Corbula elegans, *Sow.* - -	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
" Gaultina, *P. & C.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" striatula, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×			
Cucullæa (*Arca*) costellata, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
Cucullæa glabra, *Park.* -	?	.	.	.	.	.	o	.	.	.	.	.	×	.	×	o		
C. fibrosa, Sow.																		
" (*Arca*) nana, *Leym.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Cyprina regularis, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" orbiculata,* *Rœmer* -																		
" quadrata, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" ? sp. - - -	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×			
Cytherea (*Venus*) parva, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×	o		
Gastrochæna (*Fistulana*) pyriformis,† *Mant.*	.	.	.	.	.	.	.	.	.	.	.	.	×	×				
Leda Mariæ, *D'Orb.* - -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" solea, *D'Orb.* - -	.	.	.	.	.	.	o	.	.	.	.	.	×					
Lucina Sanctæ-Crucis, *P. & C.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Modiola qaudrata, *Sow.* -	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×
Mytilus Galliennei, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Neæra subandriana, *P. & C.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" (*Nucula*) undulata, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Nucula albensis, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" bivirgata, *Sow.* -	.	.	.	.	.	.	o	.	.	.	.	×	×	.	.	o		
" De Rancei, *Price* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
(? var. of *N. ovata*, Mant.)																		
" impressa, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×	o		
" Mariæ, *D'Orb* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" obtusa, *Sow.* - -	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×	o		
N. planata, Desh.																		
" ornatissima, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" ovata, *Mant.* - -	?	.	.	.	.	.	o	×	×	.	.	×	×	.	?			
" pectinata, *Sow.* -	.	.	.	.	.	.	.	.	×	×	.	×	×	×	.	o		

* Upper Greensand of Farnham.
† Phosphate bed between the Gault and Lower Greensand at Willingdon.

TABLE IV. (of Appendix I.)—Upper Greensand and Gault Fossils of the Wealden Area—*cont.*

	Upper Greensand.							Gault.						Junction Bed.	Also in			
					Also at													
—	Eastbourn.	Petersfield and Selbourne.	Alton.	Folkestone.	Warminster.	Upper Greensand and Chloritic Marl, Isle of Wight.	Cambridge.	Eastbourn.	Ringmer and Hamsey.	Bletchingley.	West Malling.	Aylesford and Maidstone.	Folkestone.	Folkestone.	Lower Greensand.	Blackdown Beds.	Hunstanton Limestone.	Chalk.
LAMELLIBRANCHIATA—*cont.*																		
Dimyaria—cont.																		
Nucula subrecurva, *Phil.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
„ Vibrayeana, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Panopæa (*Myacites*) plicata, *Sow.*	.	.	.	.	.	o	.	.	.	.	.	.	×	×	×			
Mya elongata, Römer																		
Panopæa (*Myacites*) mandibulata, *Sow.*	.	.	×	.	.	o	.	.	.	.	.	.	.	.	×			
Panopæa, ? sp. - - -	.	.	.	.	.	.	.	.	.	.	.	.	.	×				
Pectunculus (*Cardium*) umbonatus, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
Periploma (*Anatina*) simplex, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Pholadidea (*Pholas*) constricta, *Phil.*	.	.	.	.	.	.	.	.	.	.	.	.	×	×				
Pholadidea (*Pholas*), Sanctæ-Crucis, *P. & C.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Pholadidea, ? sp. - -	.	.	.	.	.	.	.	.	.	.	.	.	.	×				
Pholadomya (*Cardium*) decussata, *Phil.*	.	.	×	.	o	o	o	.	.	.	.	.	×	.	.	.	.	×
Pholadomya fabrina, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Solecurtus Dupinianus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Tellina inæqualis, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×	o		
„ Moreana, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
„ phaseolina, *Pict. & Camp.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Teredo ? sp. - - -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Thetis Sowerbyi, *D'Orb.* -	.	×	.	.	.	o	.	.	.	.	.	.	×	.	×	o		
T. major, Sow.; *T. minor*, Sow.																		
Trigonia Fittoni, *Desh.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
„ ? sp. - - -	.	.	.	.	.	.	.	.	.	.	.	.	.	×				
Unicardium (*Venus*) Ringmeriense, *Mant.*	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×
„ ? sp. - -	.	.	.	.	.	.	.	.	.	.	.	.	.	×				
Venus tenera, *Sow.* - -	.	.	.	.	.	.	.	.	.	.	.	.	×					
GASTEROPODA.																		
Acmæa tenuicosta, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Actæon affinis, *Sow.* - -	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×	o		
„ Vibrayeanus, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Alaria (*Rostellaria*) carinella, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Aporrhais (*Rostellaria*) costata, *Mich.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
„ calcarata, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×	o		
„ cingulata, *S. Woodw.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
„ elongata, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
„ marginata, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
„ Orbignyana, *P. & R.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
„ Parkinsoni, *Mant.* -	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o	.	×
„ Reussii, *Geinitz* -	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
Avellana Clementina, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
„ (*Auricula*) incrassata, *Sow.*	.	.	.	.	.	.	o	.	×	.	.	.	×	.	×	o		
„ (*Auricula*) inflata, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
„ pulchella, *Price* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Buccinum Gaultinum, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Cerithium Dupinianum, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
„ tectum, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
„ trimonile, *Mich.* -	.	.	.	.	.	.	o	.	.	.	.	.	×					
„ (other species not determined.)	.	.	.	.	.	.	.	.	.	.	.	.	×					
Cinulia, ? sp. - - -	×																	

TABLE IV. (of Appendix I.)—Upper Greensand and Gault Fossils of the Wealden Area—*cont.*

—	Upper Greensand.							Gault.						Junction Bed.	Also in			
					Also at													
	Eastbourn.	Petersfield and Selbourne.	Alton.	Folkestone.	Warminster.	Upper Greensand and Chloritic Marl, Isle of Wight.	Cambridge.	Eastbourn.	Ringmer and Hamsey.	Bletchingley.	West Malling.	Aylesford and Maidstone.	Folkestone.	Folkestone.	Lower Greensand.	Blackdown Beds.	Hunstanton Limestone.	Chalk.
GASTEROPODA—*cont.*																		
Dentalium decussatum, *Sow.*	.	.	.	.	.	.	.	.	.	×	.	.	×	×				
" ellipticum, *Sow.*	.	.	.	.	.	.	o	.	.	.	.	.	×	×	.	o		
" medium, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
" ? sp.	×																	
Fusus elegans, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Gaultinus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Iterianus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" rusticus, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
Murex calcar, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
Natica cassisius, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Clementina, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Cretacea, *Goldf.*	.	.	×															
" Gaultina, *D'Orb.*	.	.	×	.	.	o	o	.	.	×	.	.	×	.	.	o	o	
N. canaliculata, Geinitz																		
Helix Gentii, Sow.																		
" obliqua, *Price*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Pleurotomaria (*Trochus*) Gibbsii, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Pleurotomaria (*Trochus*) Gurgitis, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	o
Pleurotomaria perspectiva, *Mant.*	.	×	×	.	.	o	.	.	.	.	.	.	.	.	×	.	.	×
Pleurotomaria (*Trochus*) Rhodani, *D'Orb.*	×	×	×	.	.	o												
Pterocera (*Rostellaria*) retusa, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
Pyrula (?) Smithii, *Sow.*	.	.	.	.	.	o	.	.	.	.	.	.	×					
Rissoina incerta, *Desh.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Rostellaria (*Aporrhais*) buccinoides, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Rostellaria carinata, *Mant.*	.	.	.	.	.	.	o	×	.	×	.	.	×	×	.	o		
" maxima, *Price*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" ? sp.	×	.	.	.	.	.	.	.	.	.	.	.	.	×				
Scalaria (*Melanopsis*) Clementina, *Mich.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.			
" Dupiniana, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
" gastyna, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Gaultina, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Solarium Albense, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" conoideum, *Sow.*	.	.	.	.	.	o	.	.	.	.	.	.	×	.	.	o		
Cirrus plicatus, Sow.																		
" dentatum, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" (*Cirrus*) granulatum, *Mant.*	.	×																
" moniliferum, *Mich.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" ornatum, *Sow.*	.	.	×	×	.	o	o	?	.	.	.	×	×					
" ? sp.	×	.	.	.	.	.	.	.	.	.	.	.	.	×				
Turbo Brunneri ?, *P. & C.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Turritella granulata, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
" Vibrayeana, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
NUCLEOBRANCHIATA.																		
Bellerophina (*Ammonites*) minuta, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	×	×					
CEPHALOPODA.																		
Ammonites auritus, *Sow.*	.	.	.	.	.	.	o	×	.	.	.	.	×	.	.	o	o	×
" Austeni,* *Sharpe*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
" Benettianus, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
A. serratus, Park.																		

* Upper Greensand of Dorking.

TABLE IV. (of Appendix I.)—Upper Greensand and Gault Fossils of the Wealden Area—*cont*

—	Upper Greensand.							Gault.							Also in			
					Also at									Junction Bed.				
	Eastbourn.	Petersfield and Selbourne.	Alton.	Folkestone.	Warminster.	Upper Greensand and Chloritic Marl, Isle of Wight.	Cambridge.	Eastbourn.	Ringmer and Hamsey.	Bletchingley.	West Malling.	Aylesford and Maidstone.	Folkestone.	Folkestone.	Lower Greensand.	Blackdown Beds.	Hunstanton Limestone.	Chalk.
CEPHALOPODA—*cont.*																		
Ammonites Beudantii, *Brong.*	.	.	.	.	.	.	.	.	.	.	.	.	×	×	.	o	o	
" biplicatus, *Mant.*	.	.	.	.	.	.	.	.	×									
" Bouchardianus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
A. cristatus, Sow.																		
" catillus, *Sow.* -	×	×	×	.														
" circularis, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	×	?	×				
" cornutus, *Pict.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" crenatus, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" cristatus, *De Luc*	.	.	×	.	.	.	.	.	.	.	.	.	×					
" De la Ruei, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" denarius, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
A. parvus, Sow.																		
" Deshayesii, *Leym.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	o	
" Goodhallii, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	o		
" interruptus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	×	×	×	.			
A. dentatus, Sow.; *A. serratus*, Park.																		
" Iterianus, *Seeley* -	.	.	.	.	.	.	o	.	.	.	.	.	.	×				
" lautus, *Sow.* -	.	.	×	.	.	.	.	.	.	.	.	×	×	×	.	o	o	
" Mantelli, *Sow.* -	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×
" ornatus, *Park.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" planulatus, *Sow.* -	×	.	.	.	.	.	o	.	.	.	.	.	×	.	.	.	.	×
" Raulinianus, *D'Orb.*	.	.	.	.	.	.	o	.	.	.	.	.	×					
" Renauxianus,* *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	o
" rostratus, *Sow.* -	.	.	×	.	o	o	o	.	.	.	.	.	×	.	.	.	o	o
? *A inflatus*, Sow.																		
" Selliguinus, *Brong.*	.	.	.	.	.	o	.	.	.	.	.	.	×	.	.	.	.	×
A. lævigatus, Sow.																		
" splendens, *Sow.* -	.	×	.	.	.	o	o	×	.	×	.	×	×	×				
A. planus, Mant.																		
" symmetricus, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" tuberculatus, *Sow.*	.	.	×	.	.	?	.	.	.	.	.	×	×	.	.	o		
" varians, *Sow.* -	×	×	×	.	o	o						?	?	.	.	.		
" varicosus, *Sow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×	?	.	o	.	
" Vellidæ, *Mich.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
" versicostatus, *Mich.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Ancyloceras (*Hamites*) spinigerum, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Baculites baculoides, *D'Orb.* -	.	.	×	.	o	.	.	.	.	.	.	.	.	.	.	.	.	×
Belemnites attenuatus,† *Sow.*	.	.		.	.	.	.	×	.	.	.	.	×	.	.	o	o	
" minimus,† *List.* -	.	.	.	.	.	.	o	×	.	×	.	×	×	×	.	.	o	
B. Listeri,† Mant.																		
" ultimus,† *D'Orb.* -	×	.	.	.	o	o	o	.	.	.	.	.	×	.	.	.	o	
" ? sp. - -	.	.	×															
Conoteuthis (? C. Dupinianus, *D'Orb.*).	.	.	.	.	.	.	.	.	.	.	.	.	×					
Crioceras asterianus, *D'Orb.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Hamites armatus, *Sow.* -	.	.	×	.	.	o	.	.	.	.	.	.	×	.	.	.	.	×
H. plicatilis, Sow.																		
" attenuatus, *Sow.* -	?	.	.	.	.	.	.	×	×	.	.	.	×	?	?	.	.	×
H. tenuis, Sow. -																		
" compressus, *Sow.* -	.	.	.	.	.	.	.	.	×	.	.	.	×					

* Upper Greensand of Dorking.

† "The whole of these forms occur together in great numbers in the lower beds of the Hunstanton limestone. From a careful examination of a great number of forms, I feel convinced that they can only be regarded as varieties of one species."—J. W. JUDD, *Quart. Journ. Geol. Soc.*, Vol. xxiii., p. 251.

TABLE IV. (of Appendix I.)—Upper Greensand and Gault Fossils of the Wealden Area—*cont.*

	Upper Greensand.							Gault.						Junction Bed.	Also in			
					Also at													
	Eastbourn.	Petersfield and Selbourne.	Alton.	Folkestone.	Warminster.	Upper Greensand and Chloritic Marl, Isle of Wight.	Cambridge.	Eastbourn.	Ringmer and Hamsey.	Bletchingley.	West Malling.	Aylesford and Maidstone.	Folkestone.	Folkestone.	Lower Greensand.	Blackdown Beds.	Hunstanton Limestone.	Chalk.
CEPHALOPODA—*cont.*																		
Hamites elegans, *Park.*	.	.	.	.	.	.	.	.	.	.	.	.	×	?				
" (*Turrilites*) flexuosus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" intermedius, *Sow.*	.	.	.	.	.	.	.	.	×	×	.	×	×					
" maximus, *Sow.*	.	.	.	.	.	.	.	?	.	.	.	.	×					
H. gibbosus, Sow.																		
" nodosus, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	×			
" (*Helicoceras*) rotundus, *Sow.*	.	.	.	.	.	.	.	.	×	.	.	×	×	×				
" Sablieri ?, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" simplex, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	×
H. attenuatus, Mant.																		
" tuberculatus, *Sow.*	?	.	.	.	.	.	.	×	.	.	.	.	×					
" turgidus, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Helicoceras gracilis, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Nautilus Bouchardianus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Clementinus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" elegans, *Sow.*	.	?	×	.	o	o	.	.	.	.	.	.	.	.	×	.	.	×
N. Deslongchampsianus, D'Orb.																		
" inæqualis, *Sow.*	.	.	×	.	.	.	.	?	.	.	.	.	×	.	×			
" Largilliertianus, *D'Orb.*	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	×
" pseudo-elegans, *D'Orb.*	.	.	×	.	o	.	.	.	.	.	.	.	.	.	×	.	.	×
" ? sp.	.	×	.	.	.	.	.	.	×									
Ptychoceras (Hamites) adpressum, *Sow.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Scaphites æqualis, *Sow.*	×	.	.	.	.	o	o	.	.	.	.	.	?	.	.	.	.	×
Toxoceras, ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	×					
Turrilites Archiacianus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" asterianus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Bergeri, *Brong.*	.	.	.	.	.	o	.	.	.	.	.	.	×	.	.	.	.	×
" bituberculatus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" catenatus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" costatus, *Lam.*	×	.	.	.	.	o	.	.	.	.	.	.	.	.	.	.	.	✓
" Emericianus?, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" elegans, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Hugardianus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
" Senequieranus, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	o
VERTEBRATA.																		
PISCES.																		
Drepanephorus canaliculatus, *Ag.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Edaphodon Sedgwicki ?, *Ag.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Hybodus	.	.	.	.	.	.	.	.	.	.	.	.	×					
Ischyodus (*Chimæra*) brevirostris, *Ag.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Lamna, ? sp.	×	.	×	.	.	.	.	×	.	.	.	.	×					
Otodus appendiculatus, *Ag.*	×	.	.	.	o	o	o	.	.	.	.	.	×	.	.	.	o	×
Squalus mustelus, Mant.																		
Ptychodus acutus, *Ag.*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Pycnodus, ? sp.	.	.	.	.	.	.	.	.	.	.	.	.	×					
Pachyrhizodus glyphodus, *Blake & Mackie*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Saurocephalus lanciformis, *Harlan.*	.	.	.	.	.	.	o	.	.	.	.	.	×	.	.	.	.	×
Saurocephalus, ? sp.	.	×																
Thrissopater Salmoneus, *Günther*	.	.	.	.	.	.	.	.	.	.	.	.	×					
Fish vertebræ	.	.	.	.	.	.	.	.	.	.	.	.	×	×				

TABLE IV. (of Appendix I.)—Upper Greensand and Gault Fossils of the Wealden Area—*cont.*

—	Upper Greensand.							Gault.					Junction Bed.	Also in			
					Also at												
	Eastbourn.	Petersfield and Selbourne.	Alton.	Folkestone.	Warminster.	Upper Greensand and Chloritic Marl, Isle of Wight.	Cambridge.	Eastbourn.	Ringmer and Hamsey.	Bletchingley.	West Malling.	Aylesford and Maidstone.	Folkestone.	Folkestone.	Lower Greensand.	Blackdown Beds.	Hunstanton Limestone.	Chalk.
REPTILIA.																		
Chelonian bones - -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Ichthyosaurus campylodon, *Carter*	.	.	.	.	o	o	o	.	.	.	.	.	×	×	×	.	o	×
Plesiosaurus - - -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Polyptychodon interruptus, *Ow.*	×	.	.	.	.	.	o	.	.	.	.	.	×	.	.	.	.	×
Pterodactylus Daviesii, *Ow.* -	.	.	.	.	.	.	.	.	.	.	.	.	×					
Rhinochelys - - -	.	.	.	.	.	.	.	.	.	.	.	.	×					

TABLE V. (OF APPENDIX I.).

DISTRIBUTION OF FOSSILS IN THE GAULT OF FOLKESTONE.

BY C. E. DE RANCE, F.G.S.*

	Junction Bed.	Lower Gault.						Junction Bed.	Upper Gault.		
	I.	II.	III.	IV.	V.	VI.	VII.	VIII	IX.	X.	XI.
Chondrites fastigiatus, *Sternb.*	.	.	.	.	.	.	.	.	.	.	×
Pinites hexagonus, *Carr.*	.	.	.	.	.	.	.	.	P		
Choanites	.	.	.	.	.	.	.	.	.	.	×
Bathycyathus Sowerbyii, *Ed. & H.*	.	.	.	.	.	.	.	P			
Caryophillia Bowerbankii, *Ed. & H.*	.	.	.	.	.	.	×	×			
Cyclocyathus Fittoni, *Ed. & H.*	×	.	P	×	.	×	×	×	P		
Parasmilia ? *Sp. nov.*	.	.	.	.	.	×					
Smilotrochus elongatus, *Duncan*	.	.	.	P	P						
" insignis, *Duncan*	.	.	.	P	P						
Trochocyathus conulus, *Phil.*	P	.	.	.	×	×	.	.	.	.	P
" Harveyanus, *Ed. & H.*	.	.	P	.	P	×					
Trochosmilia sulcata, *Ed. & H.*	×	.	.	.	P	.	.	.	P		
Cidaris Gaultina, *Forbes*	.	.	.	.	.	.	.	.	.	×	
Goniaster ? Sp.	.	.	.	.	.	.	.	.	.	P	
Hemiaster asterias, *Forbes*	.	.	.	.	.	.	.	.	.	×	
" Bailyi, *Forbes*	.	.	.	.	.	.	.	.	.	P	P
" minimus, *Ag.*	.	.	.	.	.	.	.	.	.	P	×
Pentacrinus Fittoni, *Aust.*	×	.	.	.	×	.	.	.	×	×	
Serpula antiquata, *Sow.*	.	.	.	.	.	.	.	.	×	×	
" filiformis, *Sow.*	×										
" plexus, *Sow.*	.	.	.	.	.	.	.	.	.	.	P
Pollicipes rigidus, *Sow.*	.	.	P								
" unguis, *Sow.*	.	×	.	.	.	.	×	×	P	×	
Diaulax Carteriana, *Bell*	.	.	.	.	.	.	.	.	.	.	P
Etyus Martini, *Mant.*	.	.	×	×	.	.	P	.	.	P	
Homolopsis Edwardsii, *Bell*	.	.	.	.	.	P					
Hoploparia longimana, *Sow.*	.	.	×	×	.	.	.	×	.	P	
Necrocarcinus Bechii, *Deslong.*	.	.	.	.	.	×	.	.	.	×	
Palæocorystes Broderipii, *Mant.*	.	.	×	×	.	P	P				
" Stokesii, *Mant.*	.	.	.	×	.	.	P	.	×	×	
Kingena lima, *Defr.*	.	.	.	.	.	.	.	.	.	×	
Rhynchonella sulcata, *Park.*	×	.	.	.	.	.	P				
Terebratula biplicata, *Sow.*	.	.	.	.	.	.	×	P	P	×	P
Avicula Cenomanensis, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	P
" gryphæoides, *Sow.*	.	.	.	.	.	.	.	.	.	.	P
Exogyra conica, *Sow.*	×	.	P	.	.	.	.	P	P	.	P
Gervillia solenoides, *Defr.*	.	.	.	.	×						
Inoceramus concentricus, *Park.*	×	.	×	×	×	×	×	×	×	×	×
" Crispii, *Mant.*	.	.	.	.	.	.	.	.	.	.	×
" subsulcatus, *Wiltshire*	.	.	.	.	.	.	.	.	×		
" sulcatus, *Park.*	.	.	.	.	.	.	.	×	×	×	
Lima elongata, *Sow.*	.	P	×	×	.	×	×	.	P		
" globosa, *Sow.*	.	P									

* In the following list, the letter P indicates the occurrence of species in the various beds, as determined by MR. F. G. H. PRICE, and given in the lists appended to his paper, "On the Gault of Folkestone," *Quart. Journ. Geol. Soc.*, vol. XXX., p. 358. The following table shows to what extent his sub-divisions are equivalent to those adopted in the present list:—

De Rance.		Price.	
Bed XI.	=	Bed XI.	
X.	=	" X.	down to horizon of *P. Raulinianus.*
"	=	" X.	
" IVa.	=	" IV.	
" IV.	=	" III.	
" III.	=	" II.	
" II. and I.	=	" I.	Grey Clay and Phosphate Bed in one.

In supplementing the following list from that given by MR. PRICE, species occurring in his Zone II. have been put here in III.; those in his III. and IV. in IV. The beds from V. to X. are the same in both tables.—C. E. DE R.

(A vertical section of the Gault of Folkestone, by MR. DE RANCE, is given on p. 146. For synonyms of this list, see Table IV.—W. T.)

TABLE V. (of Appendix I.)—Distribution of Fossils—*cont.*

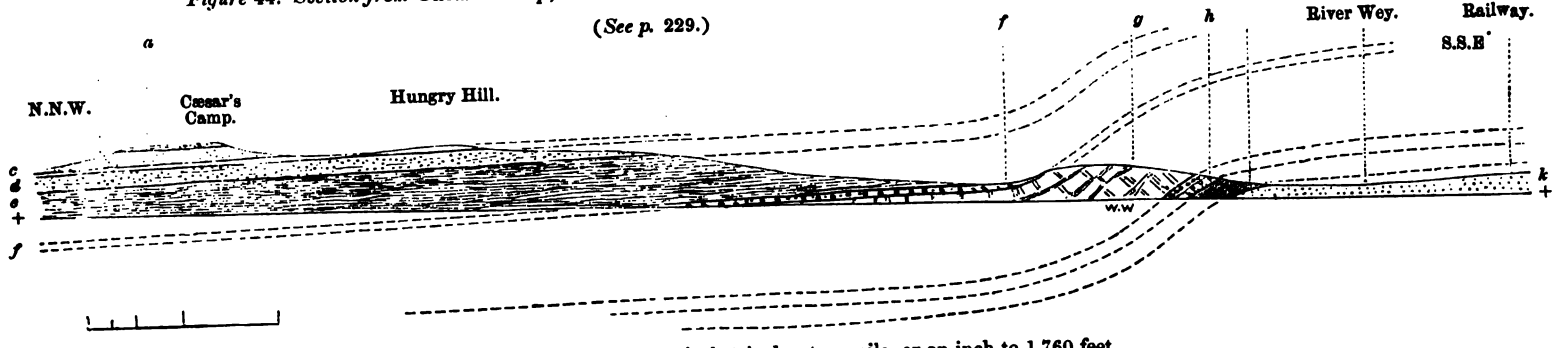
—	Junction Bed.	Lower Gault.						Junction Bed.	Upper Gault.		
	I.	II.	III.	IV.	V.	VI.	VII.	VIII	IX.	X.	XI.
Ostrea frons, *Park.*	.	.	.	.	.	.	.	.	.	.	P
„ ? Sp.	.	×	×	.	.	.	×	×			
Pecten orbicularis, *Sow.*	P	.	.	.	.	.	.	.	.	.	×
„ quadricostatus, *Sow.*	P ?	.	P ?	.	.	.	×	.	.	P ?	
„ Raulinianus, *D'Orb.*	.	.	.	.	.	.	.	×	.	×	
Pinna tetragona, *Sow.*	.	.	P	×	.	P					
„ Sp.	.	.	.	P	×						
Plicatula pectinoides, *Sow.*	×	.	×	.	.	P	.	P	.	.	×
Arca carinata, *Sow.*	.	.	P	.	.	.	.	P	P	P	
„ Hugardiana, *D'Orb.*	.	.	P	.	.	.	×	P			
Astarte Dupiniana, *D'Orb.*	.	.	.	P							
Cardita tenuicosta, *Sow.*	.	.	.	.	P	.	×	×	×	P	×
„ rotundata, *Pict.*	.	.	.	.	P	.	.	P	P		
Corbula elegans, *Sow.*	.	.	.	P	.	P	×	.	P	×	
„ Gaultina, *P. & C.*	.	.	P	.	.	.	×	.	.	×	
Cucullæa glabra, *Park.*	.	.	.	.	.	.	.	P			
Cyprina quadrata, *D'Orb.*	.	.	.	.	.	.	.	P			
Gastrochæna pyriformis, *Mant.*	×	.	.	.	.	.	.	×			
Mytilus Galliennei, *D'Orb.*	.	.	×	P	.	.	.	P			
Nucula albensis, *D'Orb.*	.	.	.	.	.	.	P				
„ bivirgata, *Sow.*	.	.	.	.	×	×	P	×	×	×	
„ Capsæformis, *Mich.*	.	.	P								
„ impressa, *Sow.*	.	.	.	.	.	P	P				
„ Mariæ, *D'Orb.*	.	.	P	P	P						
„ obtusa, *Sow.*	.	.	P								
„ ornatissima, *D'Orb.*	.	.	.	.	.	.	P	P			
„ ovata, *Mant.*	P	.	P	P	×	×	×	×	×	×	P
„ pectinata, *Sow.*	×	.	P	P	×	×	×	×	×	P	×
„ subrecurva, *Phil.*	.	.	.	P	P	.	×	×			
„ Vibrayeana, *D'Orb.*	.	.	.	.	P	.	P	P			
Panopæa plicata, *Sow.*	×	.	P								
Pholadidea constricta, *Phil.*	×	.	.	.	.	.	.	×			
„ Sanctæ-Crucis, *Pict. & Camp.*	.	.	P	.	.	.	.	P			
Pholadomya fabrina, *D'Orb.*	.	.	.	.	.	.	P	P			
Tellina phaseolina, *Pict. & Camp.*	.	.	P	.	.	P					
Thetis Sowerbyi, *D'Orb.*	.	.	.	.	.	.	.	.	.	.	×
Trigonia Fittoni, *Desh.*	P										
„ sp.	P										
Acmæa tenuicosta, *D'Orb.*	.	.	P	.	×	×	P	P			
Actæon affinis, *Sow.*	.	.	.	.	.	.	×				
Alaria carinella, *D'Orb.*	.	.	.	.	.	P					
Aporrhais cingulata, *S. Woodw.*	.	.	.	.	.	P	P	×			
„ Orbignyana, *P. & R.*	P	.	P	P	×	×	×	×	P	P	P
„ Parkinsoni, *Mant.*	.	.	.	.	.	.	×				
Avellana inflata, *Sow.*	.	.	.	.	P	P	×				
„ pulchella, *Price*	.	.	.	P	P	P	P				
Buccinum Gaultinum, *D'Orb.*	.	.	.	.	P						
Cerithium Dupinianum, *D'Orb.*	.	.	.	.	P						
„ tectum, *D'Orb.*	.	.	.	.	.	.	P				
„ trimonile, *Mich.*	.	×	P	.	×	×	×				
Dentalium decussatum, *Sow.*	×	.	P	P							
„ ellipticum, *Sow.*	×	.	.	.	.	.	×	×			
Fusus elegans, *D'Orb.*	.	.	.	.	.	P					
„ Gaultinus, *D'Orb.*	.	.	.	.	P						
„ Iterianus, *D'Orb.*	.	.	×								
Murex calcar, *Sow.*	.	.	.	.	.	.	.	P			
Natica Clementina, *D'Orb.*	.	.	×	P	P	P	×				
„ Gaultina, *D'Orb.*	.	.	×	.	×	.	×	×	.	×	P
Pleurotomaria Gibbsii, *Sow.*	.	.	.	.	.	.	.	×	P	P	
Pterocera retusa, *Sow.*	.	.	.	.	.	.	×	×			
Rostellaria carinata, *Mant.*	×	.	P	×	×	×	×	P	P		
Scalaria Clementina, *Mich.*	.	.	P	.	.	.	×				
„ Dupiniana, *D'Orb.*	.	.	?	P	.	.	P	.	.	.	P
„ gastyna, *D'Orb.*	.	.	.	.	.	P					
Solarium albense, *D'Orb.*	.	.	.	.	P	P					
„ conoideum, *Sow.*	.	.	.	.	P	P	P	×			
„ dentatum, *D'Orb.*	.	.	.	.	.	.	.	.	P		
„ moniliferum, *Mich.*	.	.	.	.	P	P					
„ ornatum, *Sow.*	.	.	.	P	.	P	P	×	P	×	P
Turbo Brunneri ?, *P. & C.*	.	.	.	.	.	.	.	.	×		
Turritella granulata, *Sow.*	.	.	.	P	.	.	P				
„ Vibrayeana, *D'Orb.*	.	.	.	.	×	.	×				
Bellerophina minuta, *Sow.*	.	.	.	×	P	P	P				

Table V. (of Appendix I.)—Distribution of Fossils—*cont.*

—	Junction Bed.	Lower Gault.						Junction Bed.	Upper Gault.		
	I.	II.	III.	IV.	V.	VI.	VII.	VIII	IX.	X.	XI.
Ammonites auritus, *Sow.*	.	.	×	.	.	P	×	P			
" Benettianus, *Sow.*	.	×									
" Beudantii, *Brong.*	×	?	.	.	.	.	.	×			
" Bouchardianus, *D'Orb.*	.	.	.	.	.	.	.	×	P		
" circularis, *Sow.*	×	.	.	.	.	.	.	.	×		
" cornutus, *Pictet*	.	.	.	.	.	×	.	P			
" cristatus, *De Luc*	.	.	.	.	.	.	.	×	P	×	
" De la Ruei, *D'Orb.*	.	.	.	P							
" denarius, *Sow.*	.	.	.	P	P	×	×	.	P		
" Deshayesii, *Leym.*	.	.	P								
" Goodhallii, *Sow.*	.	.	.	.	.	.	.	.	.	.	×
" interruptus, *D'Orb.*	×	.	.	.	.	.	.	?	.	?	
" Iterianus, *D'Orb.*	.	.	.	.	.	.	.	×			
" lautus, *Sow.*	×	.	.	.	P	P	×	P			
" lautus, var.	.	.	.	.	.	.	.	×	×	×	
" rostratus, *Sow.*	.	.	.	.	.	.	.	.	P	×	×
" Selliguinus, *Brongn.*	.	.	.	.	.	.	.	×			
" splendens, *Sow.*	.	.	.	×	×	×	×	×	×		
" splendens, grooved var.	.	.	.	.	.	.	.	×	.	.	×
" tuberculatus, *Sow.*	.	.	.	.	×	.	×	×			
" tuberculatus, var.	.	.	.	×	.						
" varicosus, *Sow.*	.	.	.	.	.	.	.	×	×	×	×
" versicostatus, *Mich.*	.	.	.	.	.	.	.	×			
Ancyloceras spinigerum, *Sow.*	.	×									
Belemnites attenuatus, *Sow.*	.	.	.	.	P	P	×	×			
" minimus, *List.*	×	.	×	.	.	P	×	×	×	×	
" ultimus, *D'Orb.*	P	.	P	.	P	P	P	P	.	×	×
Hamites armatus, *Sow.*	.	.	.	.	.	.	.	.	.	×	
" attenuatus, *Sow.*	?	.	.	P	×	×	×	×	×		
" elegans, *Park.*	?	.	P	.	.	.	.	.	.	×	
" rotundus, *Sow.*	×	.	.	.	.	.	×	.	?		
" Sablieri, *D'Orb.*	.	.	.	.	×						
" simplex, *D'Orb.*	.	.	.	.	.	.	×				
" tuberculatus, *Sow.*	.	.	.	.	×						
Helicoceras gracilis, *D'Orb.*	.	.	.	.	.	.	×				
Nautilus Bouchardianus, *D'Orb.*	P	.	.	.	.	.	.	P			
" Clementinus, *D'Orb.*	P	.	.	P	×	P	P	P	P		
" elegans, *Sow.*	.	.	.	.	.	.	.	.	×		
Fish vertebræ	×	.	P	P	P	P	×	P	×	×	×
Edaphodon Sedgwicki? *Ag.*	.	.	.	.	.	.	.	×			
Hybodus (teeth and dorsal spine)	.	.	.	.	.	.	.	.	.	P	P
Ischyodus brevirostris, *Ag.*	.	.	.	.	.	.	.	P			
Lamna (teeth)	.	.	.	.	.	.	.	×			
Otodus appendiculatus, *Ag.*	.	.	P	×	.	P	.	.	.	P	P
Pachyrhizodus glyphodus, *Blake & Mackie*	.	.	.	.	.	.	.	P			
Pycnodus (tooth)	.	.	.	.	.	.	.	×			
Saurocephalus lanciformis, *Harlan.*	.	.	.	×	.	.	.	P	.	P	P
Chelonian bones	.	.	.	.	.	.	.	.	P	P	P
Ichthyosaurian vertebræ (? I. Campylodon, *Carter.*)	×	.	.	.	.	.	.	×	.	.	×
Plesiosaurian vertebræ	×	.	.	.	.	.	.	P	.	.	P
Polyptychodon interruptus, *Owen*	.	.	.	.	.	.	P	.	P		
Rhinochelys (lower jaw), *Seeley*	.	.	.	.	.	.	.	.	.	.	P

Figure 44. Section from Cæsar's Camp, near Aldershot, by Farnham Park to the South-Eastern Railway near Farnham Station.

(*See p.* 229.)



Scale, horizontal and vertical, 3 inches to a mile, or an inch to 1,760 feet.

\+ Sea-level (approximate).

a. Gravel.
b. Upper Bagshot Beds (sand).
c. Bracklesham Beds (more clayey).
d. Lower Bagshot Beds (sand).
e. London Clay.
f. Reading Beds.
g. Chalk.
h. Upper Geensand. { Greensand. Malm rock.
i. Gault.
k. Lower Greensand.

The broken lines above show the former continuation of the beds southward, and those below their present continuation underground northward.

APPENDIX II.

List of Specimens from the Weald, exhibited in the Museum of Practical Geology.

This list is abridged, with slight addition and alterations, from the "Descriptive Catalogue of the Rock Specimens," 3rd ed., 1862. The rocks from Hastings and from the Purbeck Beds were mainly collected by Mr. C. Gould those from other localities chiefly by Mr. F. Drew. The description is by Mr. H. W. Bristow, F.R.S. The numbers to which letters are attached refer to specimens added to the collection since the Catalogue was printed.

Wall-case 6.

WEALDEN ROCKS.*

PURBECK BEDS.†

1. Compact Limestone.

Rounden Wood. N. of Brightling. Pale grey limestone with *Ostrea* ["Bottom Grey."]

The specimen is from the bottom layer of the uppermost or Main Blue limestone (*see* No. 2), which at Archer Wood is composed of a single homogeneous bed only. At Rounden Wood and Limekiln Wood, however, the "Main Blue," is composed of two distinct layers.

2. Compact Limestone.

Rounden Wood.

Grey, compact argillaceous limestone from the Main Blue. (*See* No. 1.) This bed is about twenty inches thick at Archer Wood.

3. Grey Shale.

Swife's Farm.

Grey argillaceous shales separating the Blues and Greys.

4. Compact Limestone.

Rounden Wood.

"Eight-foot Grey" bed, occuring eight feet above the Main Blue. Grey, compact, argillaceous limestone with small specks of iron pyrites. Lines of white calc spar, crystals of which also cover a portion of the original surface of the bed. The succeeding beds above this belong to the "Greys."

4*a*. Limestone, with Calcite.

Rounden Wood.

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* The fossils belonging to this formation are contained in Flat-cases 35 and 36, and in Wall-cases 25 to 27.

† These are described in the Catalogue as *Ashburnham Beds. See* the remarks on pp. 7 and 16 of this Memoir.

5. Shelly Limestone.

Poundsford, N.E. of Heathfield.

Shelly limestone from the "Bottom," a bed about 10 or 12 inches thick, composed of broken shells of *Cyrena* and *Ostrea*. At Limekiln Wood the "Bottom" and "Middle" are not shelly.

6. Shelly Limestone.

Poundsford.

Shell-limestone composed of the broken shells of *Cyrena* and containing scales of fish (*Lepidotus*). From the "Middle," a bed about 6 inches thick, which at Limekiln Wood is not shelly. The specimen retains its original grey colour in the interior, owing to the iron remaining in a state of protoxide, while the atmosphere has converted that of the exterior into peroxide.

7. Shelly Limestone.

Poundsford.

Limestone composed of broken shells of *Cyrena* and *Unio*. The joints covered with a thin coating of calc spar. From the "Top Bottom," which at Limekiln Wood is about 8 or 9 inches thick. At Poundsford the "Top Bottom," "Middle," and "Bottom" with their partings, occupy a thickness of about four feet. The "Top Bottom" and the "Grey" (No. 8) afford the best lime of the district.

8. Shelly Limestone.

Poundsford.

A thin band of shelly grey limestone with *Cyrena media*, Sow.; being the "Grey" or lowest bed in the "Vein Greys."

The "Grey" and the "Top Bottom" make the best lime. They are divided by 6 or 7 inches of shale.

9. Shelly Limestone.

Poundsford.

Compact grey limestone with numerous shells of *Cyrena*. The outer surface of the bed uneven and coated with a thin film of peroxide of iron.

The "Rotten one," a layer of limestone 6 or 7 inches thick, overlying the "Grey." At Limekiln Wood this bed is 8 or 9 inches thick.

10. Shelly Limestone.

Poundsford.

Thin-bedded limestone crowded with *Cyrena* in a perished state.

From the "Mealy" bed, consisting of shale, clay, and a thin bed of limestone 15 inches thick, separated from the "Rotten one" by the 2-inch "Bottom Vein."

11. Shelly Limestone.

Poundsford.

Thin-bedded, shelly limestone, chiefly composed of shells of *Cyrena* in a perished state, with *Lepidotus*.

From the "Fox" or "Upper Mealy." This stratum is principally composed of hard shale, some of which is still adhering to the specimen; but there is a thin bed of limestone in the middle, and another at the bottom.

12. Shelly Limestone.

Poundsford.

Grey, shelly limestone, with *Cyrena*.

"Top Vein," a band of limestone, an inch or an inch and a half thick, overlying the "Fox" or "Upper Mealy" (No. 11), from which it is separated by from 8 to 10 inches of shale.

13. SHELLY LIMESTONE.

Poundsford.

Chiefly composed of perished shells of *Cyrena*.
From the "Paver," a band of limestone 6 inches thick.

14. SHELLY LIMESTONE.

Poundsford.

Blue, shelly limestone, weathering white or slightly ferruginous, and chiefly composed of shells of *Cyrena*. From the "Main Bull," a bed of limestone about 6 inches thick, lying about 40 feet above the "Bottom" (No. 5).

ASHDOWN SAND.

15. SANDSTONE.

Hastings.

Large slab of soft yellow sandstone, showing ripple-marks; from the grounds of SIR WOODBINE PARISH. (Placed on the top shelf.)

16. SOFT SANDSTONE.

Hastings.

Soft and imperfectly consolidated, French-grey sandstone, composed of small grains of sharp, white quartz-sand.

17. SOFT SANDSTONE.

Hastings.

Ash-grey, soft sandstone, resembling No. 16.

18. LAMINATED SANDSTONE.

Hastings.

Soft and imperfectly consolidated white and buff-coloured sandstone, showing false laminations.

19. SOFT SANDSTONE.

Hastings.

Very fine, soft, and imperfectly consolidated sand-rock, with numerous casts of shells.

20. SOFT SANDSTONE.

Hastings.

Ash-grey, laminated, soft sandstone; the colour, probably, caused by finely divided carbonaceous (vegetable) matter.

20*a*. SANDSTONE.

Maresfield.

Sandstone with plant remains.

21. CLAY IRONSTONE.

Hastings.

Flattened nodule of clay ironstone, with shells of numerous freshwater fossils (*Cyrena*).

22. CONCRETION OF CLAY-IRONSTONE.

Hastings.

The core of clay ironstone is traversed with cracks in the interior, and a covered externally with a thin coating of brown iron-ore.

23. CONCRETION OF SANDY CLAY-IRONSTONE.

Snape Wood, S.W. of Wadhurst.

Similar to the preceding specimen, No. 22.

24. ROUNDED CONCRETION OF SAND.

East Cliff, Hastings.

Presented by DR. PERCY, F.R.S.

25. NODULAR CONCRETION OF SAND.

East Cliff, Hastings.

The sand is stained by ochreous oxide of iron, and incloses in the centre a nodule of clay-ironstone, which is coated externally with a thin layer of brown iron-ore.

26. NODULAR CONCRETION OF SAND.

East Cliff, Hastings.

27. ROUNDED CONCRETION OF SAND.

East Cliff, Hastings.

Similar to Nos. 24 to 26. Contains occasional and impersistent thin laminæ of pale pipe-clay.

27*a*. CONGLOMERATE.

Top bed of Ashdown Sand.

WADHURST CLAY.

28. CLAY-IRONSTONE.

Shoyswell, near Etchingham.

Clay-Ironstone, with a thin coating of peroxide, and containing numerous shells of *Cyrena.*

29. SHELLY CLAY-IRONSTONE.

Sussex.

Clay-Ironstone partially converted into peroxide. Contains numerous shells of *Cyrena.*

30. (30 *a*. and *b*.) IRON ORE.

Sussex.

A mass of casts of *Paludina* and *Cyrena,* the whole converted into peroxide of iron.

This ore is made up of a mass of freshwater snails (chiefly *Paludina*), which, together with the cementing material, consists entirely of hydrated peroxide of iron.

31. NODULAR CLAY-IRONSTONE.

Bodyham.

Nodule of fine-grained Clay-Ironstone, the exterior covered with a thin coating of peroxide.

32. IRON ORE.

N. of Ore Church, 2½ miles N. of Hastings.

33. IRON ORE.

N. of Ore Church.

Peroxide of iron, investing Clay-Ironstone.

In No. 32 only the chambered covering of peroxide is left, the Clay-Ironstone having been removed from the cavities.

34. Clay-Ironstone.

High Wood, near Netherfield.

Flattened, lenticular, concretionary nodule of Iron-ore, the centre composed of a core of ordinary Clay-Ironstone, surrounded with thin, concentric layers of peroxide of iron.

35. Grey Gritty Limestone.

¼ mile W. of Leonard Green, St. Leonard's-on-Sea.

Fissile limestone, occurring in thin beds in Wadhurst Clay.

36. Calcareous Grit. (Tilgate Stone.)

Benenden, Kent.

Fine, hard, calcareous sandstone, of a pale grey colour, and containing numerous shells. This stone occurs in thin beds, here and there, in the Wadhurst Clay.

37. Calcareous Grit. (Tilgate Stone.)

Well, St. Mary Madalene's School, St. Leonard's.

Hard, grey, calcareous sandstone, passing into a conglomerate, which is composed chiefly of small pebbles of white quartz, and containing bones of *Iguanodon.*

38. Shelly Limestone.

Near Ticehurst.

Thin-bedded, shelly limestone, composed in great part of the remains of *Cyrena.*

39. Shelly Limestone.

East of Dyke's Farm, near Penhurst, N.W. of Battle.

Thin-bedded, shelly limestone, with numerous remains of *Cyrena,* which also thickly cover both the surfaces of the stone.

39 *a.* and *b.* Clay-Ironstone.

Rolvenden.

39*e.* Siliceous Limestone.

Near Lamberhurst.

TUNBRIDGE WELLS SAND.

40. Soft Yellow Sandstone.

Goford, near Cranbrook.

A very fine-grained rock-sand, from the Lower Tunbridge Wells Sand, containing occasional very minute specks of silvery mica.

41. Sandstone.

High Beach, Hollington, Sussex.

Pale quartzose sandstone.

This stone is easily worked, takes a sharp edge, and appears to be well adapted for building purposes.

41 *a, b, c.* Mould Clay (Grinstead Clay).

Wood N.N.W. of Bolney.

This clay is locally known as "Catsbrain."

41*d.* Limestone with Calcite (Grinstead Clay).

East Grinstead.

From a well.

42. SILICEOUS GRIT.

Rolvenden.

Yellow siliceous grit, with an irony coating, showing a kind of concretionary structure.

WEALD CLAY.

43. SHELLY LIMESTONE.

Railway cutting, 3 miles S. of Redhill.

Grey shelly limestone, occurring in thin bands about the middle part of the Weald Clay. It is crowded with the shells of *Paludina.*

44. IMPURE SHELLY LIMESTONE (BETHERSDEN MARBLE).

Bethersden.

This limestone occurs in large and irregular tabular masses, which are not continuous for long distances in the direction of the strike of the beds. It is argillaceous, and full of the shells and casts of *Paludina fluviorum,* a larger species than that contained in No 43.

45. IMPURE SHELLY LIMESTONE.

Earlswood, near Reigate.

Argillaceous limestone with casts and shells of *Paludina Sussexensis* (?), occurring near the top of the Weald Clay. Similar to No. 44.

46. SHELLY LIMESTONE.

Weald of Sussex.

Impure shelly limestone, crowded with *Paludina.* Casts of that freshwater snail are crowded together on the natural surface of the stone, the other side of which is polished, to show the effect produced by the sections through the shells, which are replaced by calc spar. The darker lines of the pattern in the stone are produced by those portions of the sections of the shells which consist of the substance, composed of carbonaceous matter and phosphate of lime, which has been derived from the decomposition of the soft bodies of the snails, and which has in consequence received the name of "Molluskite" from DR. MANTELL. (*See* No. 58.) In many cases white crystalline carbonate of lime fills the whole interior of the shell. It bears a strong general resemblance to the Purbeck Marble, but may always be distinguished from it by the greater size of the shells contained in it.

47. IRON ORE.

Hythe.

Part of a concretionary nodule of brown iron-ore, with numerous *Paludina elongata,* showing its freshwater origin.

47*a*. SHELLY LIMESTONE.

Sevenoaks Tunnel.

From a shaft, at 129 feet from the surface.

47*b*. ARGILLACEOUS LIMESTONE, WITH CYRENA.

Sevenoaks Tunnel.

From No. 9 shaft, at about 190 feet from the surface.

54. GREEN CLAY.

Haslemere.

Greenish-grey clay with numerous shells of freshwater forms (*Melanopsis* or *Melania*).

LOWER GREENSAND.

Hythe Beds.

55. Lower Greensand.

Sandgate.

With *Ostrea* and other fossil shells.

56. Kentish Rag.

Great Chart, near Ashford.

Hard, grey, sandy limestone.

57. Kentish Rag.

Hythe.

Hard, bluish-grey sandy limestone.

58. Calcareous Sandstone.

Maidstone (Hassock or Calkstone).

Pale greenish-white, calcareous sandstone, with numerous dark-green specks of silicate of iron, impressions and shells of fossils, and Molluskite.
Presented by Dr. G. Mantell.

59. Chert.

Iguanodon Quarries, Maidstone, Kent.

From the Ragstone beds, where it occurs in thin zones or lenticular layers. Used for road-material.

60. Calcareous Grit. (Bargate Stone.)

Godalming.

Pale-greyish calcareous grit, consisting of minute rounded grains of translucent quartz, and green silicate of iron, &c., held together by a calcareous cement.

61. Blue Calcareous Sandstone.

Pulborough.

Forms a hard and compact building-stone.

62. Soft Yellowish Sandstone.

Pulborough.

Sandgate Beds.

63. Dark Sandy Clay.

Folkestone.

The colour of these in their natural moist state is much darker than that of the specimen, which when wetted becomes of a dark green, and appears to consist of green grains of sand bound together by clayey matter.

63*a*. Soft Green Sandstone.

South of Mill Point, Folkestone.

Folkestone Beds.

64. Greenish Calcareous Grit. (Folkestone Stone.)

Hythe [? Folkestone].

Hard, greenish-grey, and rather coarse calcareous grit.

65. PEBBLES, &c.

Guildford.

Pebbles of quartz, jasper, &c., with fragments of sandy iron-ore from the Folkestone Beds.

GAULT.

93. GAULT CLAY.

Folkestone, Kent.

Greenish-grey clay containing numerous *Rostellaria carinata.*
This clay becomes of a blue colour when in a moist state.

94. PALE GREY MARL.

Brighton.

Obtained in boring the deep well for the supply of Brighton with water at a depth of 1,130 feet from the surface.

95. GREY MARL.

Brighton.

Blue marl obtained at a depth of 1,160 feet from the surface in boring the deep well at Brighton.

96. FRAGMENTS OF SHELLS, AND PHOSPHATIC NODULES.

East Wear Bay, Folkestone.

97. SANDY CLAY.

East Wear Bay, Folkestone.

Sandy clay containing phosphatic nodules, from the upper beds of Gault, near their junction with the Upper Greensand. *See* No. 96.

97*a*. PHOSPHATIC NODULES.

Selmeston, near Lewes.

From the junction of the Gault and Lower Greensand.

UPPER GREENSAND.

111. SOFT SURREY SANDSTONE.

Farnham.

A very fine, pale-cream-coloured, soft sandstone, locally termed "*Malm rock.*"
This rock has been found to contain 40·30 per cent. of soluble silica (that is of silica soluble in solutions of caustic potash or soda, on boiling in open vessels), and 41·23 of insoluble silica, with 14·50 of alumina, &c. It furnishes a rich soil for growing hops, &c.
Presented by J. M. PAINE, ESQ.

110*a*.

Cliff, west of Eastbourn.

Top part of Upper Greensand.

110*b*. GREEN SANDSTONE.

Folkestone Tunnel.

APPENDIX III.—BIBLIOGRAPHY.

A.—GEOLOGICAL SURVEY PUBLICATIONS ON THE DISTRICT.

(The numbers in brackets refer to the order of publication of the Maps and Sections. The names in brackets are those of the principal places within the respective Sheets.)

Sheets of the Map.

(13.) Sheet 3. (Southern part.) The Beds below the Chalk by F. Drew; the Gravels of the Wealden area by W. Topley. (Some additions, unpublished as yet, have been made by C. E. Hawkins.) (Ashford.) 1868.

(4.) „ 4. By F. Drew. (Folkestone, Hythe, Romney, Rye.) 1863. The Gravels added by W. Topley.

(5.) „ 5. The Wealden lines by W. T. Aveline, H. W. Bristow, F. Drew, C. Gould, C. Le Neve Foster, W. Topley, and W. B. Dawkins. The Lower Greensand, Gault, and Upper Greensand lines by C. Gould and T. R. Polwhele. The Chalk (and Tertiary) lines by H. W. Bristow. (Lewes, Eastbourn, Hastings, Winchelsea, Tenterden, Mayfield, Uckfield.) 1864. The Gravels added by W. B. Dawkins.

(6.) „ 6. (Southern part.) The Beds below the Chalk by F. Drew. (Tunbridge, Tunbridge Wells, East Grinstead, Cranbrook, Sevenoaks, Maidstone.) 1864. 2nd Ed. with Drift lines, 1865. The Drift of the Wealden area by C. Le Neve Foster, W. Topley, and W. B. Dawkins.

(3.) „ 8. The Secondary Rocks by F. Drew (Farnham, Godalming, Guildford, Reigate). 1862. New Ed., with Wealden Gravels by W. B. Dawkins, in 1868.

(7.) „ 9. The Wealden Beds by H. W. Bristow, F. Drew, J. Hay, and F. C. Bishopp. The Lower Greensand and Gault by F. Drew and C. Gould; the Chalk (and Tertiary Beds) by H. W. Bristow; the Gravels and Alluvium by H. W. Bristow and W. B. Dawkins. (Cuckfield, Horsham, Pulborough, Midhurst.) 1864.

(1.) Sheet 11. (North-eastern part) by H. W. Bristow, the subdivisions of the Lower Greensand by F. Drew. 1858. (Petersfield.)

(2.) „ 12. (South-eastern part.) Cretaceous lines by H. W. Bristow. 1860. (Alton, Selbourne.)

Sheets of Horizontal Sections.

(12.) „ 73. Illustrates Maps 8 and 9. From the Middle Eocene strata at Selsea Bill, Sussex, to the Bagshot Sands of Chobham ridges, Surrey; across the Wealds of West Sussex and Surrey, and the Cretaceous beds of the South and North Downs, to show the relation between the Tertiary basins of Hampshire and London. By H. W. Bristow, W. Whitaker, C. Le Neve Foster, and W. Topley. 1868.

(9.) „ 75. Illustrates Maps 8 and 9. From the Chalk, west of Worthing, Sussex; across the Weald, the Lower Greensand of Leith Hill, the Upper Cretaceous beds near Dorking and Leatherhead, the Eocene formation between Fetcham and Esher, and

the Gravel and Alluvium of the valley of the Thames to Hampton, Middlesex. By H. W. BRISTOW and W. TOPLEY. 1867.

(8.) Sheet 76. Illustrates Maps 8 and 9. From the coast of Sussex, east of Kemp Town, near Brighton, across the Chalk of the South Downs, the Wealds of West Sussex and Surrey to the Chalk of the North Downs N.E. of Merstham, Surrey; showing Upper and Lower Cretaceous and Wealden beds. By H. W. BRISTOW and W. TOPLEY. 1867.

(10.) „ 77. Illustrates Maps 5 and 6. From the Lower Eocene strata and Chalk west of Newhaven Harbour, in Sussex, across the Chalk and Cretaceous strata of the South Downs, east of Lewes, the Wealds of Sussex and Kent, through Plashet Wood, and near Little Horsted, Uckfield, Buxted, and Penshurst, to the Lower Greensand of Knole Park, and the Chalk of the North Downs at a ruined Chapel two miles S.E. of Farningham, Kent. By H. W. BRISTOW and W. TOPLEY. 1867.

(11.) „ 78. Illustrates Maps 5 and 6. From the Chalk of the South Downs at Beachy Head, Sussex, to the Chalk of the North Downs near Boxley, North-east of Maidstone, Kent; across the Wealds of East Sussex and Kent, near Hailsham, Goudhurst, Marden, Linton, and Loose, showing Cretaceous and Wealden beds. Joins Section, Sheet 84. By H. W. BRISTOW, C. LE NEVE FOSTER, W. TOPLEY, and W. B. DAWKINS. 1867.

MEMOIRS.

ON SHEET 12. The Geology of parts of Berkshire and Hampshire. By H. W. BRISTOW. Lists of Fossils by R. ETHERIDGE. (Some notes on the beds below the Chalk, by F. DREW.) 1862.

ON SHEET 4. The Geology of the country between Folkestone and Rye, including the whole of Romney Marsh. By F. DREW. Lists of Fossils by R. ETHERIDGE. 1864.

The Geology of the London Basin. Part I. by W. WHITAKER (with parts, not touching the Wealden border, by H. W. BRISTOW and T. McK. HUGHES.) *Mem. Geol. Survey, Vol.* IV. 1873.

DECADES.

Decade I.	1849.	PROF. E. FORBES.	*Galerites* (*Discoidea*) *subuculus*. Lower Greensand, Hythe.
„	„	„	*Nucleolites* (*Catopygus*) *carinatus*. Hythe.
Decade IV.	1852.	„	Note on a British species of *Hemipneustes* (*Holaster complanatus*). Hythe.
„	„	„	*Ananchytes* (*Holaster*) *subglobosa*. Upper Greensand, Abinger.
Decade V.	1856.	[DR.] S. P. WOODWARD.	Notes on British Fossil *Diademas*. (*D. Mackesoni*, Forbes.) Kentish Rag, Hythe.
„	„	„	Note on *Cidaris Gaultina*, Forbes. Gault, Folkestone.
„	„	„	Note on *Salenia punctata*, Desor. Kentish Rag, Hythe.
Decade VIII.	1855.	SIR P. DE M. G. EGERTON.	*Asteracanthus granulosus*. Ferruginous grit beds of Tilgate Forest.
Decade XIII.	1872.	DR. A. GÜNTHER.	*Thrissopater Salmoneus*. Gault, Folkestone.

MINERAL STATISTICS

For 1858, Part II., embracing Clays, Bricks, &c., Building and other Stones, with sundry Earthy Minerals. By R. HUNT. 1860.

CATALOGUES.

A Descriptive Catalogue of the Rock Specimens in the Museum of Practical Geology. By A. C. RAMSAY, H. W. BRISTOW, H. BAUERMAN, and A. GEIKIE. (The Cretaceous Rocks by H. W. BRISTOW.) 3d Ed. 1862.

A Catalogue of the Collection of Fossils in the Museum of Practical Geology, with an explanatory introduction. By T. H. HUXLEY and R. ETHERIDGE. 1865.

Catalogue of Specimens in the Museum of Practical Geology, illustrative of the Composition and Manufacture of British Pottery and Porcelain. By SIR H. T. DE LA BECHE and TRENHAM REEKS. 2nd Ed. by T. REEKS and F. W. RUDLER. (Appendix A. Catalogue of Specimens illustrating the Clays and Plastic Strata of Great Britain, collected and described by GEORGE MAW, F.G.S., &c.) 8vo. 1871.

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*B.—CHRONOLOGICAL LIST OF BOOKS, PAPERS, ETC. ON THE GEOLOGY, MINERALOGY, PALÆONTOLOGY, ETC. OF THE DISTRICT.**

1596.

1. ANON. - - - The True Report of certain ground, ye quantitie of nine acres' and more, lyenge together in one trenche, which lately was moued and stirred, and carried from his former place, with the trees thereuppon, verye staunglie in ye Parish of Westram in Kent, about 16 myles from London. *4to. Lond.* (*See* HAZLITT'S *Handbook to Early English Literature*, 1867, p. 315.)

2. CHAPMAN, JOHN - A most true Report of the myraculous moving and sinking of a plot of Ground, about nine acres, at Westram, in Kent, which began the 18 of December, and so continued till the 29 of the same month, 1596. *4to. Lond.* (*See* J. RUSSELL SMITH'S *Bibliotheca Cantiana*, p. 326.) This and the foregoing seem to be the same pamphlet with different title pages.

1605.

3. VERSTEGAN, RICHARD Restitution of Decayed Intelligence, in Antiquities Concerning the most noble and renowned English nation. *4to. Antwerp.* Other Editions in 1628 and 1634 (*4to. Lond.*); and in 1655, 1673, and 1723? *8vo. Lond.*

Chap. IV. "Of the Isle of Albion, ... and how it is shewed to have been continent or firm land with Gallia, ... since the flood of Noah." [This Chapter is reprinted in DR. D. PAGE'S *Chips and Chapters*, 1869.]

1607.

4. NORDEN, JOHN - - The Surveyor's Dialogue. *4to. Lond.* (The Wealden Ironworks, &c. described, pp. 213–219.) 3rd Ed. in 1618.

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* For a knowledge of many of the following memoirs, &c., I am indebted to my colleague, Mr. W. WHITAKER. MR. BRISTOW has also favoured me with references to several papers.

1625.

5. [MARKHAM, GERVASE] The enrichment of the Weald of Kent, or a direction to the Husbandman for the true Ordering, Manuring, and Enriching of all the Grounds within the Wealds of Kent and Sussex. Painfully gathered for the good of this land, by a man of great Eminence and Worth; but Revised, Inlarged, and Corrected with the consent and by conference with the first author. *4to. Lond.* [According to J. RUSSELL SMITH (*Bibliotheca Cantiana*, p. 71) this work was first published in 1625, under the initials R. I. It was frequently reprinted. The latest edition which I have seen is that of 1683. Some copies have a Map of the Weald.]

1632.

6. ROWZEE, DR. LODWICK The Queen's Wells, that is, a Treatise on the Nature and Vertues of Tunbridge Water. *18mo. Lond.* [Reprinted in 1656 and 1671; also in *Harleian Miscellany, vol.* viii.]

1664.

7. EVELYN, J. - - Sylva, a Discourse of Forest Trees, and the Propagation of Timber in His Majesty's Dominions. *Fol. Lond.*

1673–1719.

8. AUBREY, J. - - The Natural History and Antiquities of the County of Surrey. *5 vols. 8vo. Lond.*

1674.

9. RAY, JOHN - - A Collection of English Words not generally used . . . . . with an account of the Preparing and Refining such Metals and Minerals as are gotten in England. *12mo. Lond.* [Account of Sussex Ironworks at pp. 127-129.] Later editions in 1691, 1742, and 1769.

1684.

10. HATLEY, DR. GRIFF. - A letter concerning some form'd stones found at Hunton in Kent. [Paludina Limestone in Weald Clay.] *Phil. Trans. vol.* xiv. (*No.* 155), *p.* 463.

1687.

11. MADAN, DR. P. - - A Philosophical and Medicinal Essay on the Waters of Tunbridge, ... *4to. Lond.* [Reprinted in *Harleian Miscellany, vol.* i.]

1699.

12. ALLEN, B. - - The Natural History of the Chalybeat and Purging Waters of England. *8vo. Lond.* Another edition in 1711.

1700.

13. BROME, REV. J. - Travels over England, Scotland, and Wales. [Gault Fossils at Folkestone noticed, p. 274.] 2nd Ed. in 1707.

14. WALLIS, DR. J. - A letter relating to that Isthmus or Neck of Land, which is supposed by some to have joyned England and France in former Times, where now is the Passage between Dover and Calais. *Phil. Trans. vol.* xxii. (*No.* 276), *p.* 967.

14*a*. WALLIS, DR. J. - A Second Letter relating to Mr. Somner's Treatise of Chartham News. *Ibid. p.* 1030.

15. YOUNG, JOHN - - The Improvement of the [Romney] Marsh and the Country near about it: being an Account of some Proposals for furnishing the Marsh with fresh Water . . . . . 4*to*.

1716.

16. SACKETTE, REV. JOHN A Letter giving an Account of a very uncommon sinking of the Earth, near Folkestone in Kent. *Phil. Trans. vol.* xxix. (*No.* 349), *p.* 469.

1724.

17. BUGDEN, R. . . . - Map of Sussex [showing the positions of the Ironworks.] 2nd. Ed. in 1779. [BOWEN's map, published in 1745 (?), and which also shows the Ironworks, is copied from BUGDEN.]

18. STUKELEY, DR. W. - Itinerarium Curiosum; or an Account of the Antiquities and remarkable Curiosities in Nature or Art, observed in Travels thro' Great Britain. *Fol. Lond.* [Escarpments in Kent described, p. 123.]

1725.

19. ROUSE, DR. L. - Tunbridge Wells: or, a Directory for the Drinking of those Waters. Appendix:—MR. BOYLES' Observations upon the Tunbridge-Waters. 8*vo*. *Lond.*

1728.

20. COLLINSON, P. - - An uncommon Sinking of the Ground in Kent [at Lympne]. *Phil. Trans. vol.* xxxv. (*No.* 405) *p.* 551.

1729.

21. WOODWARD, DR. J. - An Attempt Towards a Natural History of the Fossils of England. 2 *vols.* 8*vo*. *Lond.* [Vol. i. pp. 4, 16, 18, 20.]

1734.

22. WASSE, REV. J. - Account of the Shock of an Earthquake felt in Sussex, October 25, 1734.

1736.

23. BAYLEY, DR. E. - Narrative of an Earthquake in Sussex. *Phil. Trans. vol.* xxxix. *p.* 362.

24. RICHMOND, DUKE OF An account of a shock of an Earthquake felt in Sussex on the 25th of Oct.; Anno 1734. *Ibid. p.* 361.

25. SALMON, N. - - The Antiquities of Surrey . . . . with some account of the present state and Natural History of the County. 8*vo*. *Lond.*

1737.

26. PACKE, DR. C. - - A Dissertation upon the Surface of the Earth as delineated in a Specimen of a Philosophico-Chorographical Chart of East Kent. With map. 4*to*. *Lond.*

1743.

27. PACKE, DR. C. - - A new Chorographical Chart of East Kent.

28. ——————— ΟΓΚΟΓΡΑΦΙΑ, sive Convallium Descriptio; in which are briefly, but fully, expounded the Origine.

Cause, and Insertion, Extent, Elevation, and Congruity, of all the Valleys and Hills, Brooks, and Rivers; as an Explanation of a new Philosophico-chorographical Chart of East Kent. *4to. Canterbury.*

1748.

29. LINDEN, DR. D. W. A Treatise on the Origin, Nature, and Virtues of Chalybeat Waters, and Natural Hot Baths. *Lond.* Later Ed. in 1755.

1755.

30. [SEVERAL WRITERS] Effects of the Lisbon Earthquake in England. *Phil. Trans., vol.* xlix. *p.* 351.

1756.

31. ANON. - - - Account of a Landslip near Westerham. *Gent. Mag., vol.* xxvi., *pp.* 103, 172.

32. GOSTLING, REV. W. - Account of the Sinking of some land at Lymne, in Kent, in 1727. *Ibid., p.* 160.

1757.

33. ANON. - - - Notice of Elephant Bones at Burton, Sussex. *Ibid., vol.* xxvii., *pp.* 198, 588.

1758.

34. BURROW, JAS. - - An account of an Earthquake felt at Lingfield in Surrey, and Edenbridge in Kent, on the 24th of Jan. 1758. *Phil. Tans., vol.* l. *p.* 614.

1759.

35. YOUNG, ARTHUR - A Six Weeks' Tour through the Southern Counties of England and Wales.

1763.

36. ANON. - - - Natural History of Dorking. *Gent. Mag., vol.* xxxiii. *p.* 220.

1766.

37. BURR, T. B. - - The History of Tunbridge Wells. *8vo. Lond.* High Rocks, p. 48; Medicinal Waters, p. 70; Ironworks, p. 156.

1769.

38. RUSSELL, P. - - England Displayed. Travels by a Society of Gentlemen. [Edited by P. RUSSELL.] 2 *vols., fol.*

1770.

39. MONRO, DR. D. - A Treatise on Mineral Waters. 2 *vols. Lond.*

1776.

40. SMITH, DR. H. - A Treatise on the Use and Abuse of Mineral Waters. *8vo. Lond.*

1780.

41. ANON. - - - Adams Well (at Speldhurst), being as circumstantial a history of its original, and the cause of its present improvements, the high esteem it has always been held in as a drinking water, and its salutary effects in the various cases and disorders (herein described and attested) as can at present be produced. *12mo. Lond.*

1786.

42. LYON, REV. J., and E. KING. Letters giving an account of a Subsidence of the Ground near Folkstone, on the coast of Kent. *Phil. Trans., vol.* lxxvi. *p.* 220.

1789.

43. WHITE, REV. GILBERT. The Natural History and Antiquities of Selborne, in the county of Southampton. 4*to. Lond.* Numerous later Editions.

1792.

44. BABINGTON, DR. - Analysis of the Medicinal Waters of Tunbridge Wells. 8*vo. Lond.*

1793.

45. "AMICUS" - - Note on the Geology of the Cliffs between Hythe and Lympne. *Genius of Kent, or County Miscellany, for March, p.* 207.

46. YOUNG, REV. A. - General View of the Agriculture of the County of Sussex. With map. 4*to. Lond.* (Reprinted in 8vo. in 1808.)

1794.

47. BOYS, JOHN - - General View of the Agriculture of the County of Kent. 4*to. Lond.* 8vo. ed. in 1796; 2nd. ed. in 1805.

48. DRIVER, A., and W. DRIVER. General View of the Agriculture of the County of Hampshire. 4*to. Lond.*

49. JAMES, W., and JAS. MALCOLM. General View of the Agriculture of the County of Surrey. 4*to. Lond.*

1798.

50. DE LUC, J. A.- - Lettres sur l'Histoire physique de la Terre. 8*vo. Paris.* Translated by REV. H. DE LA FITE. 8*vo. Lond.* 1831. Notes by J. A. DE LUC, the younger, on the Chalk of Beachy Head, p. 202 (p. 168 of English Translation).

51. MARSHALL, W. - The Rural Economy of the Southern Counties. 2 *vols.* 8*vo. Lond.* (2nd ed. in 1799.)

1799.

52. MITCHELL, JOHN - [Letter on] the Natural History of Kent, between Bromley and Sevenoaks. *Gent. Mag., vol.* lxix. *p.* 112.

1801.

53. PENNANT, T. - - A Journey from London to the Isle of Wight. 2 *vols.* 4*to. Lond.*

1804.

54. GILPIN, REV. W. - Observations on the Coasts of Hampshire, Sussex, and Kent, relative chiefly to Picturesque Beauty; made in the summer of the year 1774. 8*vo. Lond.*

55. PAPE, REV. D. - An account of a simple and easy means by which Rye Harbour was restored. *Trans. Soc. Arts, vol.* xxii. *p.* 245.

1805.

56. DAVY, SIR H.- - On the Analysis of Soils, as connected with their improvement:—Analysis of Soil at Sheffield Park, Sussex. *Com. to Board of Agric., vol.* iv. *p.* 302.

57. MALCOLM, JAS. - A Compendium of Modern Husbandry. 3 *vols.* 8*vo. Lond.* Vol. i.—Soils, Minerals, &c. Chiefly Surrey, but also Notes on Kent and Sussex.

58. SAUNDERS, DR. W.- A Treatise on the Chemical History and Medical Powers of some of the most celebrated Mineral Waters. 2 *vols.* 8*vo. Lond.*

1806.

59. FAREY, JOHN - - MS. Geological Section of the Country from London to Brighton. (Hor. Scale 1 inch to 1 mile.) Several copies of this Section were made; one is in the Library of the Geological Society of London.

1807.

60. FAREY, JOHN - - On the Means of Ascertaining the Nature of Soils, &c., and in the Finding of Coal. *Dickson's Agric. Mag., vol.* i. *p.* 115.

61. R[AN]D, C. - - Two Letters on Coal in Sussex. *Sussex Weekly Advertiser, October 5th and 12th.*

1808.

62. BRAYLEY, E. W. - Account of the Soils, &c. of Kent. *Beauties of England and Wales, vol.* vii. *p.* 433.

63. FAREY, JOHN - - On the Finding of Coal in the South-Eastern Counties of England. *Dickson's Agric. Mag., vol.* ii. *p.* 22.

64. VANCOUVER, CHAS. - General View of the Agriculture of Hampshire, including the Isle of Wight 4*to. Lond.* 8vo. ed. in 1813 [There is some doubt as to the date of this work; the preface is dated 1808, the map 1810.]

1809.

65. STEVENSON, W. - General View of the Agriculture of the County of Surrey. 4*to. Lond.* Later ed. in 8vo., in 1813.

1810.

66. AMSINCK, PAUL - Tunbridge Wells and its Neighbourhood, illustrated by a series of Etchings [by L. BYRNE] and Historical Descriptions. 4*to. Lond.* Soils, Rocks, &c., pp. 41–46; Waters, p. 47, etc.

1811.

67. ANON - - - [Short Notices of the Search for Coal at Bexhill.] *Monthly Mag. vol.* xxxi. *pp.* 92, 392.

1812.

68. MIDDLETON, J. - Outlines of the Mineral Strata of Great Britain. *Ibid, vol.* xxxiv, *pp.* 198, 310, 393, 480.

1812–29.

69. SOWERBY, J. - - The Mineral Conchology of Great Britain. 8*vo. Lond.*

Vol. 1.—1812–15, pp. 31, 77, 87, 88, 95, 116, 136, 138, 161, 170.
„ 2.—1816–18, pp. 1, 11, 35, 86, 94.
„ 3.—1819–21, pp. 18, 27, 29, 30, 139, 183, 184, &c.
„ 4.—? 1822–3, pp. 3, 4, 43, 70, 89.
„ 5.—? 1824–5, pp. 53, 70, 106.
„ 6.—? 1826–9, pp. 7, 12, 51–52, 68, 72, 93, 104, 113, 123, 139, 176, 187–192, 196, 202–204.

1813.

70. SHOBERL, F. - - Account of the Mineral Waters, Soils, &c., of Surrey and Sussex. In *Beauties of England and Wales, vol.* xiv.

71. TOWNSEND, REV. J. The Character of Moses established for Veracity as an Historian, recording events from the Creation to the Deluge. *4to. Bath and Lond.*

1814.

72. C[URTEIS], E. J. - Letter on a Submarine Forest in Pevensey Level. *Gent. Mag., vol.* lxxxiv. *pt.* 2, *p.* 128.

73. DEARN, T. D. W. - An Historical, Topographical, and Descriptive Account of the Weald of Kent. *8vo. Cranbrook.*

74. FAREY, JOHN - - Notes and Observations on Mr. Robert Bakewell's "Introduction to Geology;"—embracing incidentally several new Points of Geological Investigation and Theory. *Phil. Mag., vol.* xliii. *p.* 119.

75. MIDDLETON, J. - The Mineralogy of Surrey. In MANNING *and* BRAY'S *Hist. of Surrey, Appendix to vol.* iii. *p.* lxxv.

1815.

76. DALLAWAY, REV. JAS. A History of the Western Division of the County of Sussex. *Fol. Lond.* Vol. i.—Observations on the Geological Phænomena, pp. cxlvi.–cl.

77. FAREY, JOHN - - Supplementary Index to Vol. I. [of SOWERBY'S *Mineral Conchology*]. Arranging the shells described therein according to the several strata in which they are found imbedded, from the newest downwards to the oldest in the British Series. SOWERBY'S *Min. Con. vol.* i. *8vo. Lond.*

78. SMITH, W. - - Map of England and Wales.

79. ——————— A Memoir to the Map and Delineation of the Strata of England and Wales, with part of Scotland. *4to. Lond.* (Surrey, Kent, and Sussex, pp. 16 and 17.)

1816.

80. SCUDAMORE, DR. C. An Analysis of the Mineral Waters of Tunbridge Wells. . . . To which are annexed some observations on the Water with which Tunbridge Wells is chiefly supplied for domestic purposes. By T. Thomson, M.D. *8vo. Lond.*

81. WEBSTER, T. - - Order of the Upper Strata of the South-East of England. In SIR H. ENGLEFIELD'S *Isle of Wight. Fol. p.* 237.

1817.

82. ANON. - - - Notice of Sulphate of Barytes from Nutfield in Surrey, with Analysis [by PROF. STROMEYER]. *Ann. Phil., Ser.* 1, *vol.* ix. *p.* 247.

83. THOMPSON, [DR.] THOS. Account of a remarkable Fossil (*Lepidotus*, from Aldfold). *Ibid., p.* 342.

84. FUSSELL, L. - - A Journey round the Coast of Kent. *8vo. Lond.*

1818.

85. WALFORD, THOS. - The Scientific Tourist through England and Wales. 2 *vols.*

1819.

86. ANDERSON, CAPT. JAS. Some observations on the peculiarity of the Tides between Fairlight and the North Foreland, with an

explanation of the supposed meeting of the Tides near Dungeness. *Phil. Tran., vol.* cix. *p.* 217.

87. [FAREY, JOHN] - Articles "Coal" and "Denudation" in REES' *Cyclopædia, vol.* viii and xi. *4to. Lond.* [Probably some other geological articles in this cyclopædia were written by MR. FAREY.]

88. MANTELL, [DR.] G. A. A Sketch of the Geological Structure of the South-Eastern part of Sussex. *Gleaner's Portfolio or Provin. Mag., p.* 8. *8vo. Lewes.*

89. PARKINSON, J. - Remarks on the Fossils collected by Mr. Phillips, near Dover and Folkestone. *Trans. Geol. Soc.,* (*Ser.* 1,) *vol.* v. *p.* 52. (Read, Jan. 16th—Feb. 20th 1818.)

90. PHILLIPS, W. - - Remarks on the Chalk Cliffs in the neighbourhood of Dover, and on the Blue Marl covering the Greensand near Folkestone. . . . . *Ibid., p.* 16. (Read, Jan 2nd 1818.)

91. SMITH, W. - - Geological Maps of Kent, Sussex, and Surrey.

92. ——————— Geological View and Section of the Country from London to Brighton, through Lewes.

1820.

93. SCUDAMORE, DR. C.- A Chemical and Medical Report of the Properties of the Mineral Waters of Buxton and Tunbridge Wells. *8vo. Lond.*

1821.

94. MANTELL, [DR.] G. A. Letter on a Fossil Vegetable from Tilgate Forest. *Ann. Phil., Ser.* 2, *vol.* i. *p.* 68.

95. WEBSTER, T. - - On the Geognostical Situation of the Reygate Stone, and of the Fuller's Earth at Nutfield. *Trans. Geol. Soc.,* (*Ser.* 1), *vol.* v. *p.* 353. (Read, May 1st 1819.)

1822.

96. CONYBEARE, REV. W. D., and W. PHILLIPS. Outlines of the Geology of England and Wales. *8vo. Lond.*

97. CRICHTON, SIR A. - Notice on Some Fossil Shells from Langton-Green, near Tunbridge Wells. *Trans. Geol. Soc., Ser.* 2, *vol.* i. *p.* 173. (Read, April 19th 1822.)

98. MANTELL, [DR.] G. A. The Fossils of the South Downs, or Illustrations of the Geology of Sussex. *4to. Lond.*

99. VETCH, CAPT. - - Notice on a Fossil Bone found in the neighbourhood of Cuckfield. *Ann. Phil., Ser.* 2, *vol.* iv. *p.* 69.

1823.

100. YEATS, DR. G. D. - On the Waters of Tunbridge Wells. *Journ. Sci. and Arts, vol.* xiv. *p.* 345.

1824.

101. ANON [...STOKES and ...WEBB.] Description of some Fossil Vegetables of the Tilgate Forest, in Sussex, [with a Notice of the Localities by DR. MANTELL]. *Trans. Geol. Soc., Ser.* 2, *vol.* i. *p.* 423. (Read, June 7th 1822?)

102. BUCKLAND, DR. W. Notice on the Megalosaurus or Great Fossil Lizard of Stonesfield. *Ibid, p.* 391. (Read, Feb. 20th 1824.)

103. FITTON, DR. W. H. Notes on Parts of the opposite Coasts of the English Channel, from Deal to Brighton, and from Calais to Treport. *Ann. Phil., Ser.* 2, *vol.* viii. *p.* 67.

104. FITTON, DR. W. H. Inquiries respecting the Geological Relations of the Beds between the Chalk and the Purbeck Limestone, in the South-East of England. *Ibid.*, *pp.* 365, 458. [Reprinted, with additions, for private distribution. 4to. 1833.]

105. MANTELL, [DR.] G. A. Notice accompanying some specimens from the Blue Chalk Marl [Gault] of Bletchingley. *Trans. Geol. Soc., Ser.* 2, *vol.* i. *p.* 421. (Read, Jan. 17th, 1823.)

106. ——— Outlines of the Natural History of the Environs of Lewes. HORSFIELD'S *History of Lewes.* 4*to. Lewes. Vol.* i. *Appendix* 1.

107. WEBSTER, THOS. - Observations on a Comparison between the Beds below the Chalk in the Isle of Wight, and in the Counties of Surrey, Kent, and Sussex. *Ann. Phil., Ser.* 2, *vol.* viii. *p.* 465.

1825.

108. MANTELL, [DR.] G. A. Notice on the Iguanodon, a newly discovered fossil reptile, from the sandstones of Tilgate Forest, in Sussex. *Phil. Trans., vol.* cxv. *p.* 179.

109. SCROPE, G. P. - - Considerations on Volcanoes. 8*vo. Lond. Chap.* x., *pp.* 200–219.

110. SEDGWICK, REV. PROF. A. On the Origin of Alluvial and Diluvial Formations. *Ann. Phil., Ser.* 2, *vol.* ix. *p.* 241, and *vol.* x. *p.* 18. ("Wealds of Kent," p. 19.)

111. WEBSTER, THOS. - Reply to Dr. Fitton's Paper in the "Annals of Philosophy" for November. [1824. Vol. viii. pp. 365, 458. *Ibid, p.* 33.]

1826.

112. BUCKLAND, DR. W. On the Formation of the Valley of Kingsclere and other valleys by the elevation of the Strata that enclose them; and on the Evidences of the original continuity of the Basins of London and Hampshire. *Trans. Geol. Soc., Ser.* 2, *vol.* ii. *p.* 119. (Read, Feb. 8th, 1825.)

113. MANTELL, [DR.] G. A. Remarks on the Geological Position of the Strata of Tilgate Forest. *Ed. New Phil. Journ., vol.* i. *p.* 262.

114. ——— On the Iron-Sand Formation of Sussex. *Trans. Geol. Soc., Ser.* 2, *vol.* ii. *p.* 131. (Read, June 14th 1822.)

115. MURCHISON, [SIR] R. I. Geological Sketch of the North-western Extremity of Sussex, and the adjoining Parts of Hants and Surrey. *Ibid, p.* 97. (Read, December 16th 1825.)

116. WEBSTER, THOS. - Observations on the Strata at Hastings, in Sussex. *Ibid, p.* 31. (Read, June 4th 1824.)

1827.

117. ANON. - - - Discovery of Fossil Hyænas in Kent. *Phil. Mag., Ser.* 2, *vol.* ii. *p.* 73.

118. BASTEROT, B. DE. - On the Strata near Folkestone. *Trans. Geol. Soc., Ser.* 2, *vol.* ii. *p.* 334. (Read, Dec. 1st, 1826.)

119. FITTON, DR. W. H. - Additional notes on part of the opposite coasts of France and England, including some account of the Lower Boulonnais. *Proc. Geol. Soc., vol.* i. *p.* 6.

120. MANTELL, [DR.] G. A. Illustrations of the Geology of Sussex, containing a view of the Geological relations of the South-Eastern part of England, with descriptions of the Fossils of Tilgate Forest. 4*to. Lond.*

121. MANTELL, G. A. [DR.] On the Fossils of Tilgate Forest. *Proc. Geol. Soc., vol.* i. *p.* 10.

122. MARTIN, P. J. - On the Geology of the Vicinity of Pulborough, Sussex. *Proc. Geol. Soc., vol.* i. *p.* 19.

1828.

122a. BRONGNIART, A. - Histoire des Vegetaux Fossiles . . . . *4to. Paris.*

123. HARWOOD, DR. W. - On the Curative Influence of the Southern Coast of England; especially that of Hastings. *8vo. Lond.* [Geology of Hastings, *p.* 16.]

124. MARTIN, P. J. - A Geological Memoir on a part of Western Sussex; with some observations upon Chalk-Basins, the Weald-Denudation, and Outliers-by-protrusion. *4to. Lond.* [Letter by DR. W. H. FITTON on the Sands of the eastern part of Kent, p. 37.]

1829.

125. ANON. (A.B.) - - [Short note on the] Claw of the Iguanodon. *Phil. Mag., Ser. 2, vol.* v. *p.* 153.

126. BUCKLAND, DR. W. On the Discovery of Coprolites, or Fossil Fœces, in the Lias at Lyme Regis, and in other Formations. *Trans. Geol. Soc., Ser. 2, vol.* iii. *p.* 223. (Read, Feb. 6th, 1829.)

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